Hungarian Meteorological Service
Greenhouse Gas Inventory Division

National Inventory Report for 1985-2009

Hungary

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EXECUTIVE SUMMARY

ES.1. Background information

Pursuant to the United Nations Framework Convention on Climate Change (UNFCCC), Hungary, as a Party of the Convention, has been preparing annual inventories of greenhouse gas emissions using the IPCC methodology since 1994. The aim of a greenhouse gas (GHG) inventory is to give a complete and accurate as possible, state of the art estimation of anthropogenic emissions by sources and removal by sinks of greenhouse gases not controlled by the Montreal Protocol. In accordance with the Kyoto Protocol, the following direct greenhouse gases are taken into account: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The quality of the inventory is controlled by Hungarian and international experts regularly.

The GHG inventory is compiled by the Hungarian Meteorological Service, based on a government decree. Also other institutions and external experts are involved in the process of inventory preparation, e.g. the Hungarian Central Statistical Office, Energy Efficiency, Environment and Energy Information Agency, Research Institute for Animal Breeding and Nutrition, Karcag Research Institute of University of Debrecen, just to name a few. The participation of the Forestry Directorate of the Central Agricultural Office (CAO, Forestry Directorate) together with the Forest Research Institute is now formalized by a governmental decree.

The main purpose of this National Inventory Report is to describe the input data and calculation methodologies on which the emissions estimates are based thus increasing the transparency of the inventory. The present report refers to the inventory time series for the years 1985-2009. The NIR provides relevant background information on institutional arrangements, QA/QC procedures and other information underlying the inventory compilation in Chapter 1. In Chapter 2 the trends for aggregated greenhouse gas emissions are discussed. The following chapters provide detailed information on each of the main source categories. Chapter 10 discusses details of recalculations and planned improvements. In the Annexes key category analysis and complementary methodological information can be found.

ES.2. Summary of National Emissions and Removal Related Trends

In 2009, total emissions of greenhouse gases in Hungary were ***66.7 million tonnes*** carbon dioxide equivalents (excluding the LULUCF sector). This is by far *the lowest value* in the whole time series (1985-2009). Taking also into account the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 63.6million tonnes CO_2 eq. in 2009. With about 6-7 tonnes, the Hungarian per capita emissions are below the European average.

By ratifying the Kyoto Protocol, Hungary committed to reducing its GHG emissions by 6%. Now, our emissions are 41.4% lower than in the base year (average of 1985-87). For the most part, this significant reduction was mainly a consequence of the regime change in Hungary (1989-90) which brought in its train radical decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors like energy, industry and agriculture. Then, between 2005 and 2009, after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 16.1 per cent.

The global financial and economic crises (2007-2010) exerted a major impact on the output of the Hungarian economy, consequently on the level of GHG emissions as well. Emissions (excluding LULUCF) decreased by 8.7% (-6.4 million tonnes) between 2008 and 2009. In comparison with 2008, emissions in 2009 were lower in all major sectors. The highest relative reduction (-17.1%) occurred in the industrial processes sector mainly due to lower production volumes especially in mineral product manufacturing (-28.9%). Regarding absolute changes in emissions, out of the 6.4 million tonnes reduction, fuel combustion was responsible for about 4.9 million tonnes. Although energy demand increased in the heating season due to less favorable weather conditions, the fall in the production of energy intensive sectors led to an overall decline in energy use.

The most important greenhouse gas is carbon dioxide accounting for 75.7% of total GHG emissions. The main source of CO_2 emissions is burning of fossil fuels for energy purposes, including transport. CO_2 emissions have decreased by 40.4% since the middle of the 80's. Methane represents 12.6% in the GHG inventory. Methane is generated mainly at waste disposal sites and in animal farms, but the fugitive emissions of natural gas are also important sources. CH_4 emissions are 31.3% lower than in the base year. Nitrous oxide contributes 10.1% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N_2O emissions are 59.8% lower compared to base year. The total emissions of fluorinated gases amount to 1.6%. F-gas emissions are showing a fluctuating, slightly growing tendency especially due to their applications in the cooling industry.

Table ES. 1. *Base year=average of 1985-87*

GREENHOUSE GAS EMISSIONS (CO_2-eq, Gg)	Base year	1990	1995	2000	2005	2007	2008	2009
CO_2, without LULUCF	84,582.1	72,125.5	61,196.1	58,299.8	60,731.4	57,611.9	56,101.5	50,442.8
CH_4, without LULUCF	12,197.2	11,684.2	9,426.5	9,567.0	8,986.9	8,753.4	8,554.4	8,385.2
N_2O, without LULUCF	16,821.0	12,710.1	7,325.2	8,266.1	8,759.8	8,038.5	7,201.8	6,759.2
HFCs	0.0	NA,NO	0.7	222.0	600.3	807.6	936.1	851.3
PFCs	268.5	270.8	166.8	211.3	209.4	2.4	2.4	1.7
SF_6	81.0	39.9	70.1	140.1	201.0	171.6	231.9	219.7
Total (excluding LULUCF)	**113,949.8**	**96,830.5**	**78,185.6**	**76,706.2**	**79,488.9**	**75,385.4**	**73,028.1**	**66,659.8**

ES.3. Overview of Source and Sink Category Emission Estimates and Trends

GREENHOUSE GAS EMISSIONS (CO_2-eq, Gg)	Base year	1990	1995	2000	2005	2007	2008	2009
Energy	82,121.9	69,897.8	60,239.3	57,244.8	59,237.8	56,014.4	54,920.5	50,079.4
Industrial Processes	11,021.8	8,860.4	5,467.9	6,302.0	7,073.4	6,180.9	5,058.9	4,195.7
Solvent and Other Pr. Use	284.5	226.3	205.2	213.7	366.3	366.1	406.3	340.1
Agriculture	17,549.5	14,555.2	8,724.5	9,124.0	8,853.4	8,953.1	8,829.7	8,309.7
LULUCF	-2,161.7	-1,949.7	-5,781.4	-363.8	-4,221.1	-2,688.3	-3,933.4	-3,018.6
Waste	2,972.0	3,290.8	3,548.7	3,821.7	3,957.9	3,870.9	3,812.8	3,735.0
Total (including LULUCF)	**111,788.1**	**94,880.8**	**72,404.2**	**76,342.4**	**75,267.8**	**72,697.1**	**69,094.8**	**63,641.2**

By far, the biggest emitting sector was the energy sector contributing 75.1% to the total GHG emission in 2009. Agriculture was the second largest sector with 12.5% while emissions from industrial processes (with solvent and other product use) accounted for 6.8% and the waste sector contributed 5.6%. Compared to the base year, emissions were significantly reduced in the energy (-39.0%), agriculture (-52.7%), and industrial processes (-61.9%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+25.7%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.

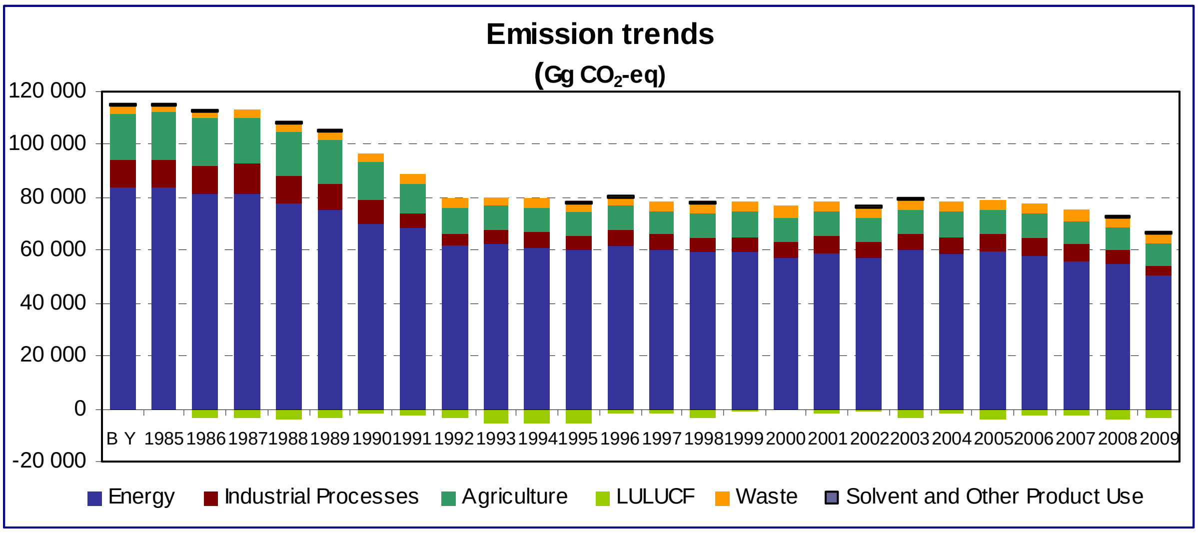


Figure ES. 1. *Change in greenhouse gas emissions from base year (1985-2009)*
Note: BY=average of 1985-87 but 1995 for F-gases

The ***energy sector*** was responsible for 75.1% of total GHG emissions in 2009. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.3% to sectoral emission. Considering fuel use, gases had the highest proportion (49.6%), liquids and solids represented 28.6% and 14.0%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 6.9%. The most important subsector was energy industries with a proportion of 32.6% within the energy sector, followed by other sectors (26.9%) and transport (25.3%). Fugitive emissions from fuels played only a small role with 4.4%. The most dynamically increasing category was transport which had 63.3% higher total emission in 2009 compared to the base year.
The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation which caused sudden decrease in energy demand. Besides, ongoing changes in fuel-structure, i.e. solid fuel as the most important source in the 80's had been replaced by natural gas, led to further decrease of total emission.
Overall emissions from the energy sector decreased by 8.8% between 2008 and 2009. Electricity production and net consumption were 5.7% lower than in 2008. Besides, share of nuclear and renewable energy further increased in 2009, therefore the lower amount and lower share of fossil fuels used for electricity and heat production resulted in 16.5% decrease in emissions from energy industries. The continuous growing tendency of transport emissions stopped after a more than 80% increase between 1995 and 2007; emissions even decreased by 1.6% in 2009. The total amount of biofuel use was nearly the same as in 2008. The tertiary sector used nearly the same amount of energy, but its emission also decreased by 2% due to the higher share of biomass.

In 2009, ***agriculture*** was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH_4 and N_2O gases: almost 85 percent of total N_2O emissions were generated in agriculture in 2009. Emissions from agriculture decreased

by 52.7% over the period of 1985-2009. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 15.4% to its present share of 12.5%.
Between 1996 and 2008, agricultural emissions stagnated around 9Mt with fluctuations up to 5%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers increased by 67.5% until 2007 which caused growing nitrous-oxide emissions from agricultural soils. In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels.
Agricultural emissions fell by 5.9 percent between 2008 and 2009. This reduction was mainly driven by the 7.1% decrease in the emissions from agricultural soils, primarily due to the 6.5 per cent reduction of fertilizer use. Although fertilizer prices decreased during 2009, they stayed relatively high, especially at the beginning of the year, which lead to lower synthetic fertilizer use. Besides, the lower harvested production resulted in lower emissions from crop residues in agricultural soils compared to its high level in 2008. The continued decline in animal population resulted in further decrease in emissions from the Agriculture sector. Mainly the decrease in swine population caused declining methane emissions here. Although the forage prices were more favorable than in 2008, the falling profitability of swine farming in private farms resulted in an 11 percent reduction of the swine population.

The ***industrial processes*** sector was the third largest contributing 6.3% to total GHG emissions in 2009. (Solvent and other product use added further 0.5% to total emissions.) The most important greenhouse gas was CO_2, contributing 73.5% to total sectoral GHG emissions, followed by F-gases with 25.6%. Within this sector, 38.5% of the emissions came from mineral products, followed by 25.6% from consumption of halocarbons and SF_6 and 20.4% from non-energy use of fuels. Process related industrial emissions decreased by 61.9% between base year and 2009, and by 40.7% between 2005 and 2009.
The key driver of the 17.1% (-0.9 Mt) reduction between 2008 and 2009 was the mineral production. Cement production decreased by 23%, lime production by 35%, whereas the drop in ceramics and brick production was not less than 79%! The relatively smaller (15%) increase in ammonia and nitric-acid production went against the general trend in the industrial processes sector.
Although emissions of F-gases represent only 1.6% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission increased tenfold. Nevertheless, also emissions from consumption of F-gases decreased by 8.3 per cent between 2008 and 2009.

The ***waste*** *sector* represented 5.6% of total national GHG emissions in 2009. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+25.7%). However, the growth of emissions seemed to be stopping in recent years, moreover a reduction of 5.6% could be observed between 2005 and 2009. In all the years, the largest category was solid waste disposal on land, representing 80.1% in 2009, followed by wastewater handling (18.0%) and waste incineration (1.9%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade.

In the ***Land Use Land-Use Change and Forestry*** sector, using the currently available data, carbon uptake of the forests living biomass, non-CO_2 emissions from burning of slash on-site, and for the last couple of years, forest wildfires are reported. Overall, the sector is a sink of carbon because of the huge amount of carbon uptake of forests, due to continuous afforestation efforts and sustainable forest management. In the inventory period, the forest area increased by 350,000 hectares, and the amount of the current annual increment

exceeded the annual harvest in all years. The complex dynamics of the land use and land-use changes leads to highly fluctuating estimates of sectoral removals. Our estimates indicate an average annual 2.9 million tonnes removal, CO_2-eq. net removals range from 0.09 million tonnes in 1985 to 5.8 million tonnes CO_2 in 1995. In 2009 the LULUCF sector accounted for 3.0 million tonnes carbon-dioxide removals. The removals of forests amounted to 3.2 million tonnes, while the living biomass of orchards and vineyards were a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. The emission of the living biomass of vineyards and orchards accounted for 0.25 million tonnes CO_2 in 2009.
Our mineral soils used for agricultural purposes remove a small amount of carbon (0.22 Mt in 2009), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favourable processes that increase the soil carbon content.

As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.1 million tonnes CO_2-eq. mainly due to afforestation and reforestation in 2009. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 1.9 million tonnes CO_2-eq.

ES.4. Indirect Greenhouse Gases and SO_2

NO_X, CO and NMVOC gases are referred to as indirect gases because they (together with SO_2) influence atmospheric warming indirectly, via secondary effects. Nitrogen oxides, carbon monoxide and (non methane) volatile organic compounds are precursor of ozone which is itself a naturally occurring greenhouse gas. Sulphur dioxide can contribute to formation of aerosols that scatter some of the solar radiation back into space. Calculation of the emissions of these gases was required by the IPCC 1996 Revised Guidelines and the CRF software provided a certain level of information technology background. It should be noted that Hungary (as well as the other European countries) has calculated the emissions of such gases for several decades and the Geneva Convention of 1979 (CLRTAP) also laid down such obligations.
The following table shows the main trends in emissions:

Table ES 2. *Emissions of indirect gases. The database is not complete for the 80's.*

Indirect gases	*1985*	*1990*	2000	2003	2005	2006	2007	2008	2009
NO_X, Gg	*262.5*	*238*	185.08	210.70	203.15	202.44	185.43	169.00	154.45
CO, Gg	*931.1*	*997*	592.66	599.66	588.20	594.31	576.70	570.45	553.67
NMVOC, Gg	*232*	*205*	166.01	168.91	176.23	186.71	167.68	168.41	133.79
SO_2, Gg	*1,403.6*	*1,010*	488.96	347.83	146.65	123.11	98.59	105.59	89.37

The substantial reduction in sulphur dioxide emissions (-95%) is attributable to the decreased use and lower sulphur content of fossil fuels. After 2000, further reductions were observed due to the introduction of SO_2 precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. NO_X and NMVOC emissions showed no significant trend in the last 15 years.

1. INTRODUCTION

1.1. Background information and climate change

Hungary submitted the First National Communication in 1994 when the country joined the UN Framework Convention on Climate Change (hereinafter referred to as the Convention). In conjunction with this, the greenhouse gas inventories of the preceding years were prepared. Since then, inventories have been compiled annually as required. According to the Convention, the year 1990 considered as general reference level was not adequate for Hungary as a base year because the economic output of the country in this period was already on the descending course as a result of the ongoing transition to market economy. Instead of 1990, the average of years 1985, 1986 and 1987 (hereinafter referred to as "base year") was selected because these three years represented a certain level of stability in the fluctuating economic output. This request was accepted by the COP.
With the introduction of additional greenhouse gases, it was necessary to select the corresponding base years. (This is particularly important for HFCs because such gases have been increasingly used since the early 1990's as replacements for ozone depleting chlorofluorocarbons.) Hungary has chosen the year 1995 as the base year for fluoride gases.
The process of inventory preparation has been improved year by year. The inventory teams did their best to meet the changing and growing requirements. Particular emphasis was placed on determining the specific emission factors for Hungary.
In early March 2007 the Expert Review Team of UNFCCC made a thorough in-depth in-country review. During this review a few potential problems were found. In collaboration between the ERT and the Hungarian experts, these problems could be fixed. However, some recalculations were necessary which led to changes also in the emissions of the base year and consequently in the assigned amount. The fixed base year emission of Hungary is 115,397.149 Gg. Hungary's assigned amount is calculated as 542,366,600 tonnes CO_2 equivalent.
The regional effects of the global climate change can clearly be seen on the Hungarian observations. The annual averages of temperature in Hungary are very similar to the well-known wave of the global temperature since the beginning of the 20th century. 2009 was the 6th warmest year since 1901 (the homogenized, interpolated dataset is available from the beginning of the 20th century) in Hungary (Fig. 1.1).

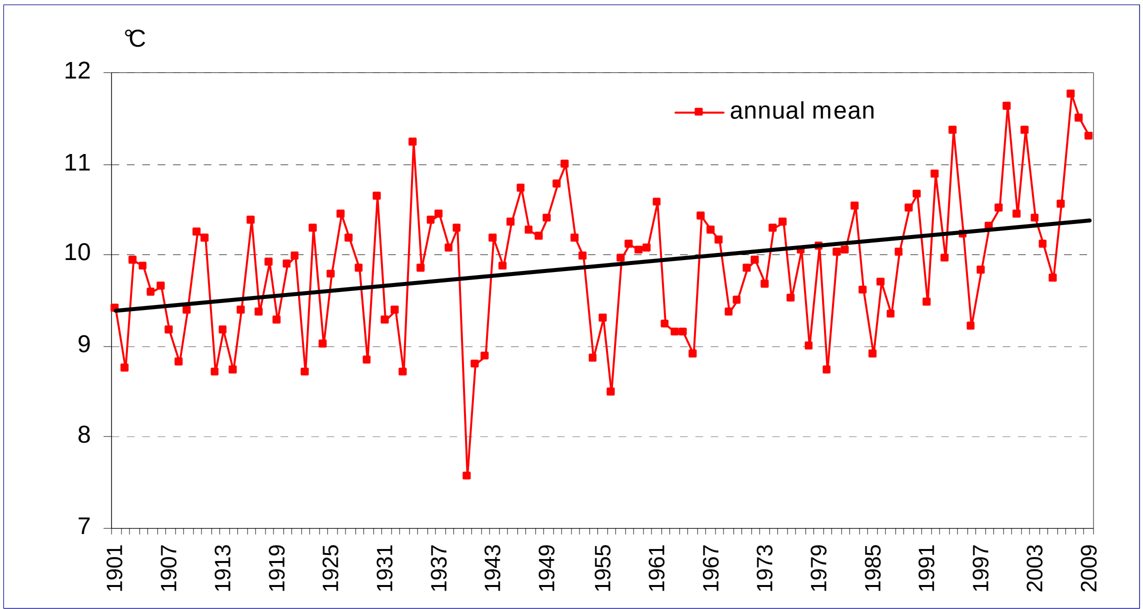


Figure 1.1. *Annual mean temperature (℃) in the period 1901-20 09 in Hungary*

The annual mean temperature was 11.3°C that was 1.3 °C warmer than the annual average (mean of 1971-2000 period). The five warmest years occurred also at the end of the period. The monthly temperature exceeded the average in every month, except January. (Fig. 1.2.).

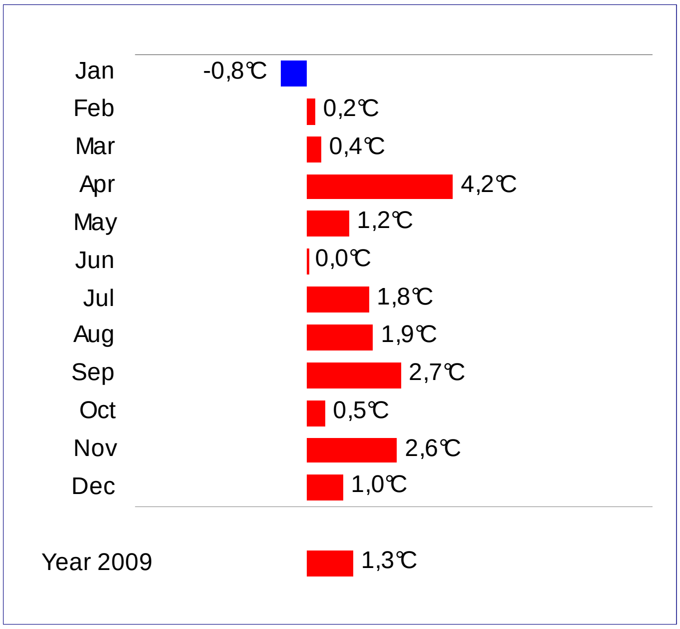


Figure 1.2. *Anomalies (compared to 1971-2000 mean) of the countrywide monthly mean temperatures in 2009 in Hungary (ºC)*

The yearly total precipitation in 2009 (598 mm) was around the average. The exponential trend fitted to the 109 year-long data series shows moderate declining (Fig. 1.3.). The sum of countrywide amount set was out 105% of the long time average. Monthly amounts and anomalies varied heavily within the year (Fig 1.4.).

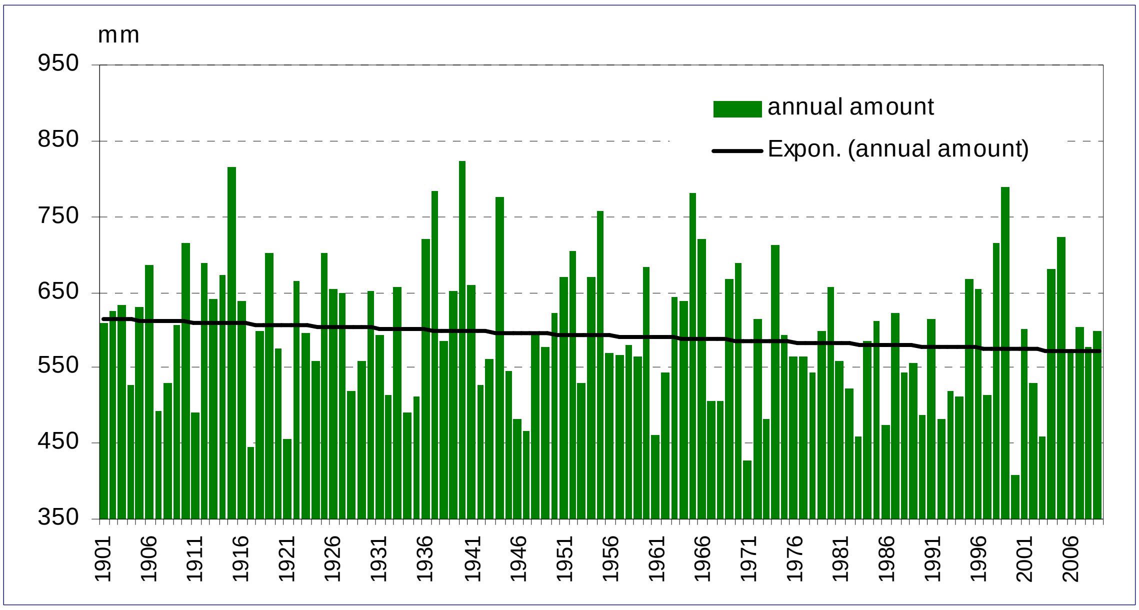


Figure 1.3. *Annual precipitation sum (mm) in the period 1901-2009 in Hungary*

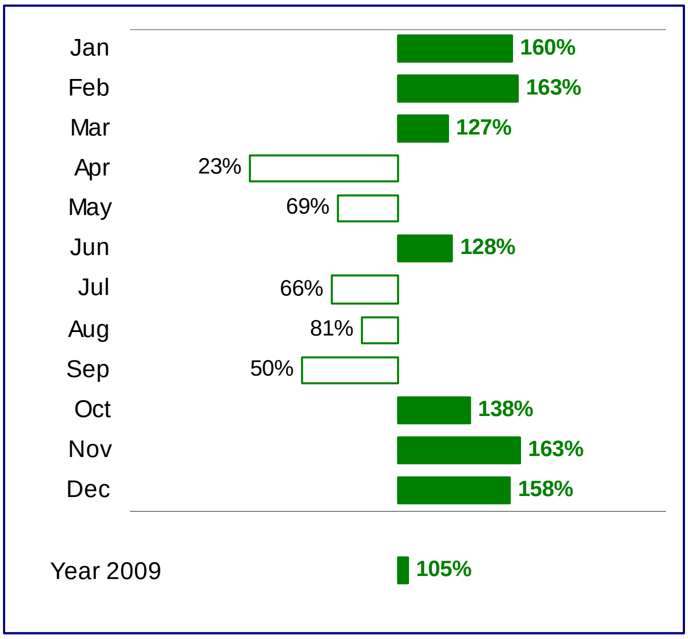


Figure 1.4. *Monthly precipitation averages (%) in 2009 compared to the reference period (1971-2000 mean) in Hungary*

1.2. Institutional arrangements

The minister responsible for the environment has overall responsibility for the Hungarian Greenhouse Gas Inventory and the Hungarian National System for Climate Reporting. He is responsible for the institutional, legal and procedural arrangements for the national system and the strategic development of the national inventory. Since the Ministry of Environment and Water had been abolished after the elections in spring 2010, and its tasks have been taken over by the Ministry of Rural Development, the designated *single national entity* is now the Ministry of Rural Development. As a new feature, the national system has to be operated by the minister responsible for the environment like earlier but, as prescribed by legislation, in consent and cooperation with the ministers responsible for energy policy and forest management. Within the Ministry of National Development, i.e. the ministry responsible for energy policy, a Climate Policy Department has been established that plays some coordinating and supervisory role in the national system. The head of this department is Hungary's new UNFCCC Focal Point. (See Ch. 13. Information on changes in national system.)

At the end of 2006, a Greenhouse Gas Inventory Division (GHG division) was established in the Hungarian Meteorological Service (OMSZ) for the preparation and development of the inventory. This division is responsible for all inventory related tasks, compiles the greenhouse gas inventories and other reports with the involvement of external institutions and experts on a contractual base and supervises the maintenance of the system.

At the very end of 2009, a new government decree on data provision relating to GHG emissions was put into force. This decree confirmed the designation of the Hungarian Meteorological Service as the compiler institute. As a new element, the participation of the Forestry Directorate of the Central Agricultural Office (CAO, Forestry Directorate) together with the Forest Research Institute is now formalized by this decree. These two institutes are responsible for the forestry part of the LULUCF sector and for the supplementary reporting on LULUCF activities under Articles 3.3 and 3.4 of the Kyoto Protocol by way of making recommendations to HMS of the content of the inventory.

The Hungarian Meteorological Service is a central office under the control of the Ministry of

Rural Development. The duties of the Service are specified in a Government Decree from 2005. The financial background of operation is determined in the Finances Act. OMSZ has introduced the quality management system ISO 9001:2000 for the whole range of its activities in 2002 to fulfill its tasks more reliably and for the better satisfaction of its partners. The GHG Inventory Division is reporting directly to the president of the Service.

The GHG division of the Hungarian Meteorological Service coordinates the work with other involved ministries, government agencies, consultants, universities and companies in order to be able to draw up the yearly inventory report and other reports to the UNFCCC and the European Commission. The GHG division can be regarded as a core expert team of four people. The division of labor and the sectoral responsibilities within the team are laid down in the QA/QC plan and other official documents of OMSZ. The Head of Division coordinates the teamwork and organizes the cooperation with other institutions involved in inventory preparations. He is responsible for compilation of CRF tables and NIR. Within the team there are coordinators of the different sectors and also a QA/QC coordinator and an archive manager were nominated.

Some parts of the inventory (mainly energy, industrial processes and waste are prepared by the experts of the GHG division themselves. The calculations of agriculture and LULUCF (except forestry) sector are compiled by the HMS with contribution of external experts / institutions on contractual basis as follows. The forestry related parts are compiled by the Central Agricultural Office and the Forest Research Institute as prescribed by government decree. For the calculation of emissions from agricultural soils Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) was contracted like in the last three years. The Research Institute for Animal Breeding and Nutrition has been heavily involved in the calculations for the agriculture sector of the inventory for several years. The following table summarizes the institutional arrangements:

Function	***Institution***	***Responsibilities***
Single national entity	Ministry of Environment and Water	• Supervision of national system • Official consideration and approval of inventory
Inventory coordination and compilation	OMSZ GHG division	• Provision of work plan • Contracting consultants • Inventory preparation of Energy, Industry and Waste sector • Completion of CRF and NIR • Archiving • Coordinating QA/QC activities • Reporting to UNFCCC secretariat
Inventory preparation of Forestry and LULUCF activities under the KP. (by law)	Central Agricultural Office (CAO, Forestry Directorate) Forest Research Institute	• Data collection, choice of methods and EFs, inventory preparation
Contribution to the inventory preparation of Agriculture sector	Research Institute for Animal Breeding and Nutrition	• Data collection, choice of method, development of country specific emission factors • Background studies
Agricultural soils	Karcag Research Institute of University of Debrecen	• Data collection, choice of methods and EFs, background research and studies

1.3. Inventory preparation

The annual inventory cycle is carried out in accordance with the principles and procedures set out in the IPCC (1996) Guidelines and the IPCC Good Practice Guidance.
As a general method of preparing the inventory, the procedures described in the IPCC Guidelines are applied and the latest CRF Reporter software is used. Usually, the sectoral experts are responsible for the choice of methods and emission factors. According to the recommendations of the IPCC Guidelines, the calculation methods are chosen by taking into account the technologies available in Hungary whenever possible. The calculation of emissions occurs basically by using the formula: AD x EF, where the activity data (AD) can be raw material or product or energy use etc. Part of the available data (e.g. production data) can directly be entered into the IPCC tables; others required previous processing and conversion. For example, energy data are not always available in the required depth and resolution. The default emission factors (EF) are being gradually replaced by country-specific emission factors characteristic of domestic technologies. Efforts are made to use the highest possible Tier method, especially in case of key categories. After preliminary quality control of the basic data, the necessary calculations are carried out with the coordination of the core team. The sectoral data are compiled and - after repeated checks - unified by using the CRF Reporter software.
Recalculation of some data-series of the inventory can be justified by several reasons. Just to name a few, QA/QC procedures, ERT recommendations, changing for higher Tier methodologies can lead to a recalculation. As a basic rule, whenever new information emerges that improves the quality or accuracy of the emission data, the emissions are recalculated. Recalculations are always documented in the relevant chapter of the national inventory report.
As described above, the GHG Division at the Hungarian Meteorological Service compiles the GHG inventory. In other words, the compiler institute makes a recommendation of the content of the inventory to the Minister of Environment and Water. Following the regulations of the above-mentioned new government decree on data provision relating to GHG emissions, official submission can only be made after ministerial approval of the recommended inventory. In practice, the GHG inventory is submitted by the Hungarian Meteorological Service.

1.4. Data collection, processing and storage

Data collection happens in several ways and throughout the whole yearly cycle of the inventory preparation. Sector specialists of the core team (or external experts on contractual basis) are making the data inquiry and collection. Data are collected from the emitter if it is possible (especially in case of power stations, heating stations and industrial technologies) but statistical databases are also heavily used as source of information. The most important statistical publications are the Statistical Yearbook of Hungary, the Environmental Statistical Yearbook of Hungary and the Environmental Report of Hungary published by the Hungarian Central Statistical Office (HCSO) and the Energy Statistical Yearbook published by the Energy Efficiency, Environment and Energy Information Agency. Since the use of ETS data has several advantages, the inventory team was granted access to the verified emissions database held by the National Inspectorate for Environment, Nature and Water. In addition to statistical data, contacts were established with the representatives of a number of major emitting sectors. Moreover, information from the web sites of international associations (e.g., International Iron and Steel Institute, IISI) is used as well. For the calculation of fluoride gas emissions, import data from the Customs Office and Police were used together with data obtained directly from companies importing and using fluorinated gases and information from cooling industry associations.
The Act LX of 2007 on the implementation framework of the UN Framework Convention on Climate Change and the Kyoto Protocol thereof aims to give direct data collection

authorization to the Ministry for Environment and Water in order to collect data for the national system for climate reporting and gives a permanent status to the system. Relevant paragraphs for data collection are the following: “The state authorities having disposal of the data necessary to operate the National Registration System and the organizations emitting at least 100 tons of carbon dioxide equivalent per year shall provide these data for the National Registration System in accordance with the provisions of a separate legal instrument.” “The data (…) necessary to fulfill international data supply shall be provided for the National Registration System irrespective of the fact that they are qualified as individual data pursuant to the relevant provision of Act XLVI of 1993 on statistics.” This separate legal instrument, the above-mentioned government decree on data provision relating to GHG emissions prescribes compulsory data provision for GHG inventory purposes for numerous governmental bodies and emitters.

A copy of all data, information necessary for the compilation of the given annual inventory is stored in printed or electronic form either by the expert team or by the institutions involved in inventory preparations. Significant steps were taken to create a central archive in the premises of the Hungarian Meteorological Service where all background data would be stored.

The most important paper information archived already in the Service is the following:

- Statistical Yearbooks of Hungary from the year 1961
- Environmental Statistical Yearbook of Hungary from 1996
- Energy Statistical Yearbook published by the Energy Efficiency, Environment and Energy Information Agency from 1985.
- Hungarian Statistics on Road Vehicles (in electronic format since 2000)
- National, regional and local emission survey of the Hungarian road, rail, water-borne and air transport (1995-2004) made yearly by the Institute of Transport Sciences

Lots of background data are stored by contracted expert institutions as well, which increases the security of data availability. Nevertheless, at least a copy of all information will be transferred to OMSZ in the near future. The following information is stored elsewhere:

- Data from individual industrial plants – Ministry of Rural Development
- ETS data, registry - National Inspectorate for Environment, Nature and Water
- Agricultural data (livestock, manure, fertilizer etc.) - Research Institute for Animal Breeding and Nutrition
- Soil-classification - Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (TAKI)
- Forestry statistics – Central Agricultural Office Forest Directorate
- Wastewater data – National Inspectorate for Environment, Nature and Water + Research Institute for Environmental and Water Management.

Electronic information is stored on disks on a fileserver with a regular backup. The whole data files are backed up once a week, while the implements (those files that have been modified since the last saving) are saved two times a week. The data are stored on tape storage system. The cassettes of the data storage system are stored far from the recording system, in another room, which is air conditioned and equipped with an up-to-date fire service system. All events connected with the data saving are logged in accordance with the documents of the Quality Assurance System of OMSZ.

The directories of the server, where the data of the GHG Division are stored have access protection, so they are available only for the staff of the Division in charge of the different sectors of the GHG inventory. It is important to note that there are different directories for all the calculations and drafts (working folder) and for the submitted reports and incoming data which cannot be modified. Within the GHG Division of OMSZ, the nominated archive manager is responsible for the maintenance of the archiving system in close cooperation with the IT Department of the Service. A procedural manual for the management and maintenance of archiving system is under preparation. A harmonized or maybe unified computerized database containing all the data relevant to the National System as well as for the EU emission trading regime is under development. Further development of the system may include the incorporation of other emission data, which are relevant to air pollution.

1.5. Brief general description of methodologies and data sources used

The IPCC Guidelines provide methodologies for estimating emissions and removals of greenhouse gases. However, the basic idea is not greenhouse gas specific, the same approach is used for other pollutants, and other emission inventories, as well (e.g. see the EMEP/EEA air pollutant emission inventory guidebook). The basic equation is as simple as this:

$$\text{Emission} = \text{AD} \times \text{EF},$$

where AD stands for activity data which represents some human activity (e.g. fuel use, industrial production, animal population, dwellings supplied with public sewerage, area of vineyard abandonment), whereas EF is the emission factor that quantifies the emission (or removal) per unit of activity. For example, in energy industry, which is the most important source category, emission factors for combusting natural gas or lignite are 56.1 t CO_2 / TJ and 108.3 t CO_2 / TJ, respectively; the importance of the mix of fuels used to produce energy becomes apparent at a glance.

Emission factors are usually dependent on several other factors, used technologies etc. which leads us to the concept of tiers. A tier represents a level of methodological complexity. In the Guidelines usually three tiers are provided. Tier 1 is the basic method, where activity data are usually aggregated national statistics and the emission factors are default values representing typical process conditions. Higher tier methodologies are more demanding in terms of complexity and data requirements as they require country-specific information on the used technologies, facility level data whenever possible, or use of complex models. For key categories, i.e. categories that have a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals, it is required to apply higher tier methods. Accordingly, the compilers of the Hungarian inventory aim at taking into account the technologies available in Hungary to the extent possible. For example, the emission trading system of the European Union makes possible to have access to facility level activity and verified emission data.

Although this basic equation can widely be used, in some source categories other approaches are used. For example, mass balance method is used for estimating the change in carbon content of living biomass in forests, or in case of solid waste disposal sites, a calculation method is applied which assumes that the degradable organic component in waste decays slowly throughout a few decades.

To ensure that the national inventory fulfils its main purpose, namely monitoring the country's compliance with its commitments, it has to meet certain quality standards, in other words it has to be accurate, complete, consistent, comparable and transparent (ACCCT). The first two requirements need no special explanation: an inventory is accurate, if it has no systematic bias towards under- or overestimations, whereas a complete inventory covers all relevant sources and sinks, and gases within the borders of the country. The next two criterions are closely linked to the requirements of the UNFCCC. Consistency ensures that the trends in the times-series of the inventory reflect real differences in emissions, and not caused by any methodological changes. National greenhouse gas inventories of all countries shall be comparable; therefore the submitted information shall be compiled in accordance with the UNFCCC reporting guidelines and the IPCC guidelines and good practice guidance.

More detailed source specific information on used data and methodologies can be found in Chapters 3-9 in this inventory report.

1.6. Key source categories

Key sources have been identified using Tier 1 methodology in accordance with the guidance of the GPG for several years. Since last year more detailed categories (with LULUCF) have been taken in key category analysis in line with the requirements of the European Union. The analysis with Tier 2 methodology was also made following the categorization of previous years. The required uncertainty values were determined on the basis of the GPG but estimates of data supplier institutions and experts were used as well. Since uncertainty estimates are not available for the LULUCF sector, Tier 2 method was applied to find key categories only for source categories (without LULUCF). All greenhouse gases and sectors were taken into account for both analyses. In order to identify the key categories, both the LEVEL and the TREND analysis were performed.
Using the concept of “Combined uncertainty” from the Tier 2 methodology, LEVEL 2 and TREND 2 identified 14 and 15 key sources, respectively.

Table 1.1. *Tier 2 Key category analysis*

Level 2 key categories			**Trend 2 key categories**		
4. D. 1.	Direct N_2O Emissions from Agricultural Soils	N_2O	4. D. 1.	Direct N_2O Emissions from Agricultural Soils	N_2O
4. D. 3.	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	4. D. 3.	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O
6. B.	Emissions from Wastewater Handling	N_2O	1. A.	Stationary Combustion - Gas	CO_2
1. A.	Stationary Combustion - Gas	CO_2	1. A. 3. B.	Mobile Combustion - Road	CO_2
1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH_4	1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH_4
6. A.	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	1. A.	Stationary Combustion - Coal	CO_2
4. B.	N_2O Emissions from Manure Management	N_2O	1. A. 3.	Mobile Combustion	N_2O
1. A. 3. B.	Mobile Combustion - Road	CO_2	1. A.	Stationary Combustion - Oil	CO_2
1. A.	Stationary Combustion - Coal	CO_2	4. B.	N_2O Emissions from Manure Management	N_2O
1. A. 3.	Mobile Combustion	N_2O	2. F. 7.	SF_6 Emissions from Electrical Equipment	SF_6
4. B	CH_4 Emissions from Manure Management	CH_4	4. B	CH_4 Emissions from Manure Management	CH_4
4. A	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	2. A. 7.	CO_2 Emission from Other Mineral Products	CO_2
2. F.	Emissions from Substitutes for Ozone Depleting Substances	HFCs	2. G.	Feedstocks and non-energy use of fuels	CO_2
4. D. 2.	Pasture, range and paddock manure	N_2O	2.	N_2O Emission from Industry	N_2O
			1. B. 1.	Fugitive Emissions from Coal Mining and Handling	CH_4

Results of key category calculation with LULUCF are summarized in *Table 1.2*. LEVEL and TREND methods found 45 and 43 key categories, respectively.

Table 1.2. *Tier 1 Key category analysis*

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
1. ENERGY				
Stationary Combustion Public electricity and heat production (1A1a)	**CO_2**	**Yes**	**L,T**	**L:so,ga,li,ot;T: so,ga,li**
Stationary Combustion Public electricity and heat production (1A1a)	CH_4	No		
Stationary Combustion Public electricity and heat production (1A1a)	N_2O	No		
Stationary Combustion Petroleum refining (1A1b)	**CO_2**	**Yes**	**L,T**	**L:li,ga;T:li**
Stationary Combustion Petroleum refining (1A1b)	CH_4	No		
Stationary Combustion Petroleum refining (1A1b)	N_2O	No		
Stationary Combustion Manuf. of solid fuels and other energy industries (1A1c)	CO_2	No		
Stationary Combustion Manuf. of solid fuels and other energy industries (1A1c)	CH_4	No		
Stationary Combustion Manuf. of solid fuels and other energy industries (1A1c)	N_2O	No		
Stationary Combustion Iron and steel (1A2a)	**CO_2**	**Yes**	**L,T**	**L:so,ga;T:so,ga, li**
Stationary Combustion Iron and steel (1A2a)	CH_4	No		
Stationary Combustion Iron and steel (1A2a)	N_2O	No		
Stationary Combustion (1A2b)	CO_2	No		
Stationary Combustion (1A2b)	CH_4	No		
Stationary Combustion (1A2b)	N_2O	No		
Stationary Combustion Chemicals (1A2c)	CO_2	No		
Stationary Combustion Chemicals (1A2c)	CH_4	No		
Stationary Combustion Chemicals (1A2c)	N_2O	No		
Stationary Combustion Pulp, paper and print (1A2d)	CO_2	No		
Stationary Combustion Pulp, paper and print (1A2d)	CH_4	No		
Stationary Combustion Pulp, paper and print (1A2d)	N_2O	No		
Stationary Combustion Food processing, beverages and tobacco (1A2e)	**CO_2**	**Yes**	**L,T**	**L:ga;T:li**
Stationary Combustion Food processing, beverages and tobacco (1A2e)	CH_4	No		

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Stationary Combustion Food processing, beverages and tobacco (1A2e)	N_2O	No		
Stationary Combustion Other (1A2f)	**CO_2**	**Yes**	**L,T**	**L:ga,li,so;T:ga,so,li**
Stationary Combustion Other (1A2f)	CH_4	No		
Stationary Combustion Other (1A2f)	N_2O	No		
Mobile combustion Civil aviation (1A3a)	CO_2	No		
Mobile combustion Civil aviation (1A3a)	CH_4	No		
Mobile combustion Civil aviation (1A3a)	N_2O	No		
Mobile combustion Road transportation (1A3b)	**CO_2**	**Yes**	L,T	L:ld,lg;T: lg,ld
Mobile combustion Road transportation (1A3b)	CH_4	No		
Mobile combustion Road transportation (1A3b)	**N_2O**	**Yes**	**L,T**	**L:lg; T: lg**
Mobile combustion Railways (1A3c)	**CO_2**	**Yes**	**L**	**L:li**
Mobile combustion Railways (1A3c)	CH_4	No		
Mobile combustion Railways (1A3c)	N_2O	No		
Mobile combustion Navigation (1A3d)	CO_2	No		
Mobile combustion Navigation (1A3d)	CH_4	No		
Mobile combustion Navigation (1A3d)	N_2O	No		
Stationary Combustion Commercial/institutional (1A4a)	**CO_2**	**Yes**	**L,T**	**L:ga;T:ga. li, so**
Stationary Combustion Commercial/institutional (1A4a)	CH_4	No		
Stationary Combustion Commercial/institutional (1A4a)	N_2O	No		
Stationary Combustion Residential (1A4b)	**CO_2**	**Yes**	**L,T**	**L:ga,so,li;T:so,li,ga**
Stationary Combustion Residential (1A4b)	**CH_4**	**Yes**	**T**	**T:so**
Stationary Combustion Residential (1A4b)	N_2O	No		
Stationary Combustion Agriculture/Forestry/Fisheries (1A4c)	**CO_2**	**Yes**	**L,T**	**L:li,ga;T:li,so**
Stationary Combustion Agriculture/Forestry/Fisheries (1A4c)	CH_4	No		
Stationary Combustion Agriculture/Forestry/Fisheries (1A4c)	N_2O	No		

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Fugitive Emissions from Fuels Solid Fuels (1B1a)	CO_2	No		
Fugitive Emissions from Fuels Solid Fuels (1B1a)	**CH_4**	**Yes**	**T**	
Fugitive Emissions from Fuels Solid Fuels (1B1a)	N_2O	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2a)	CO_2	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2b)	CO_2	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2c)	CO_2	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2d)	CO_2	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2a)	CH_4	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2b)	**CH_4**	**Yes**	**L,T**	
Fugitive Emissions from Fuels Oil and Natural Gas (1B2c)	CH_4	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2d)	**CH_4**	**Yes**	**L, T**	
Fugitive Emissions from Fuels Oil and Natural Gas (1B2a)	N_2O	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2b)	N_2O	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2c)	N_2O	No		
Fugitive Emissions from Fuels Oil and Natural Gas (1B2d)	N_2O	No		
2. INDUSTRIAL PROCESSES				
Mineral Products Cement production (2A1)	**CO_2**	**Yes**	**L**	
Mineral Products Lime production (2A2)	**CO_2**	**Yes**	**L,T**	
Mineral Products Limestone and dolomit use (2A3)	**CO_2**	**Yes**	**L**	
Mineral Products Asphalt roofing (2A5)	CO_2	No		
Mineral Products Road paving with asphalt (2A6)	CO_2	No		
Mineral Products Other (2A7)	**CO_2**	**Yes**	**T**	
Mineral Products Other (2A7)	CH_4	No		
Mineral Products Other (2A7)	N_2O	No		
Chemical Industry Ammonia production (2B1)	**CO_2**	**Yes**	**L,T**	

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Chemical Industry Ammonia production (2B1)	CH_4	No		
Chemical Industry Ammonia production (2B1)	N_2O	No		
Chemical Industry Nitric acid production (2B2)	CO_2	No		
Chemical Industry Nitric acid production (2B2)	**N_2O**	**Yes**	**T**	
Chemical Industry Other (2B5)	CO_2	No		
Chemical Industry Other (2B5)	CH_4	No		
Chemical Industry Other (2B5)	N_2O	No		
Metal Production Iron and steel production (2C1)	CO_2	No		
Metal Production Iron and steel production (2C1)	CH_4	No		
Metal Production Ferroalloys production (2C2)	CO_2	No		
Metal Production Ferroalloys production (2C2)	CH_4	No		
Metal Production Aluminium production (2C3)	CO_2	No		
Metal Production Aluminium production (2C3)	CH_4	No		
Metal Production Aluminium production (2C4)	PFCs	No		
Other Production (2D)	CO_2	No		
Production of Halocarbons and SF6 (2E)	HFCs	No		
Production of Halocarbons and SF6 (2E)	PFCs	No		
Production of Halocarbons and SF6 (2E)	SF_6	No		
Consumption of Halocarbons and SF6 Refrigeration and air conditioning equipment (2Fa1)	**HFCs**	**Yes**	**L**	
Consumption of Halocarbons and SF6 Refrigeration and air conditioning equipment (2Fa1)	PFCs	No		
Consumption of Halocarbons and SF6 Refrigeration and air conditioning equipment (2Fa1)	SF_6	No		
Consumption of Halocarbons and SF6 Foam blowing (2Fa2)	HFCs	No		
Consumption of Halocarbons and SF6 Foam blowing (2Fa2)	PFCs	No		
Consumption of Halocarbons and SF6 Foam blowing (2Fa2)	SF_6	No		
Consumption of Halocarbons and SF6 Fire extinguishers (2Fa3)	HFCs	No		

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Consumption of Halocarbons and SF6 Fire extinguishers (2Fa3)	PFCs	No		
Consumption of Halocarbons and SF6 Fire extinguishers (2Fa3)	SF_6	No		
Consumption of Halocarbons and SF6 Aerosols (2Fa4)	HFCs	No		
Consumption of Halocarbons and SF6 Aerosols (2Fa4)	PFCs	No		
Consumption of Halocarbons and SF6 Aerosols (2Fa4)	SF_6	No		
Consumption of Halocarbons and SF6 Electrical equipment (2Fa8)	HFCs	No		
Consumption of Halocarbons and SF6 Electrical equipment (2Fa8)	PFCs	No		
Consumption of Halocarbons and SF6 Electrical equipment (2Fa8)	SF6	No		
Consumption of Halocarbons and SF6 Other (2Fa9)	HFCs	No		
Consumption of Halocarbons and SF6 Other (2Fa9)	PFCs	No		
Consumption of Halocarbons and SF6 Other (2Fa9)	SF_6	No		
Feedstocks (2G1)	**CO_2**	**Yes**	**L, T**	
Nonenergy use (2G2)	CO_2	No		
3. SOLVENT AND OTHER PRODUCT USE				
Paint Application (3a)	CO_2	No		
Degreasing and Dry Cleaning (3b)	CO_2	No		
Other (3d)	**N_2O**	**Yes**	**L, T**	
4. AGRICULTURE				
Enteric Fermentation (4A1)	**CH_4**	**Yes**	**L,T**	ca
Enteric Fermentation (4A2)	CH_4	No		bu
Enteric Fermentation (4A3)	**CH_4**	**Yes**	**L**	sh
Enteric Fermentation (4A4)	CH_4	No		ot
Manure Management (4B1)	CH_4	No		ca
Manure Management (4B2)	CH_4	No		bu
Manure Management (4B3)	CH_4	No		sh

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Manure Management (4B4)	CH_4	No		ot
Manure Management (4B8)	**CH_4**	**Yes**	**L,T**	**sw**
Manure Management (4B12)	N_2O	No		liq
Manure Management (4B13)	**N_2O**	**Yes**		**so**
Rice Cultivation (4C)	CH_4	No		
Agricultural Soils Direct soil emissions (4D1)	CH_4	No		
Agricultural Soils Direct soil emissions (4D1)	**N_2O**	**Yes**	**L,T**	
Agricultural Soils Pasture, range and paddock manure (4D2)	N_2O	No		
Agricultural Soils Indirect emissions (4D3)	CH_4	No		
Agricultural Soils Indirect emissions (4D3)	**N_2O**	**Yes**	**L,T**	
Field Burning of Agricultural Residues (4F)	CH_4	No		
Field Burning of Agricultural Residues (4F)	N_2O	No		
5. LAND USE, LAND-USE CHANGE AND FORESTRY				
Forest Land, remaining (5A1)	**CO_2**	**Yes**	**L,T**	
Forest Land, remaining (5A1)	CH_4	No		
Forest Land, remaining (5A1)	N_2O	No		
Forest Land, land converted to (5A2)	CO_2	No		
Forest Land, land converted to (5A2)	CH_4	No		
Forest Land, land converted to (5A2)	N_2O	No		
Cropland, remaining (5B1)	**CO_2**	**Yes**	**L**	
Cropland, remaining (5B1)	CH_4	No		
Cropland, remaining (5B1)	N_2O	No		
Cropland, land converted to (5B2)	**CO_2**	**Yes**	**L, T**	
Cropland, land converted to (5B2)	CH_4	No		
Cropland, land converted to (5B2)	N_2O	No		

Key category analysis summary – with LULUCF

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Grassland, remaining (5C1)	**CO_2**	**Yes**	**L, T**	
Grassland, remaining (5C1)	CH_4	No		
Grassland, remaining (5C1)	N_2O	No		
Grassland, land converted to (5C2)	**CO_2**	**Yes**	**L, T**	
Grassland, converted to (5C2)	CH_4	No		
Grassland, land converted to (5C2)	N_2O	No		
Settlements, remaining (5E1)	CO_2	No		
Settlements, remaining (5E1)	CH_4	No		
Settlements, remaining (5E1)	N_2O	No		
Settlements, land converted to (5E2)	CO_2	No		
Settlements, land converted to (5E2)	CH_4	No		
Settlements, land converted to (5E2)	N_2O	No		
6. WASTE				
Solid Waste Disposal on Land (6A)	**CH_4**	**Yes**	**L,T**	
Waste (6B1)	CH_4	No		
Waste (6B2)	**CH_4**	**Yes**	**L**	
Waste (6B1)	N_2O	No		
Waste (6B2)	N_2O	No		
Waste Incineration (6C)	CO_2	No		
Waste Incineration (6C)	CH_4	No		
Waste Incineration (6C)	N_2O	No		

Abbrevations in this table:

li – liquid fuels
so – solid fuels/ solid manure management systems
ga – gaseous fuels
ot – other fuels/ other livestock categories
bi – biomass
lr – liquid fuels, residual fuel oil
ld – liquid fuel, diesel oil

lg – liquid fuel, gasoline
liq – liquid manure management systems
lu – liquid fuel, lubricants
sc – solid fuel, coal
lk – liquid fuel, kerosene
ll – liquid fuel, LPG
gn – gaseous fuel, natural gas
ca – cattle
bu –buffalo
sh – sheep
sw – swine

1.7. QA/QC information

The national system has to ensure high quality of the inventory, i.e. to ensure that the inventory is transparent, consistent, comparable, complete and accurate. These principles guide the internal expert team that maintains the system. QA/QC activities are performed in two levels: based on the ISO 9001 standards and following the IPCC recommendations.

ISO activities

The Hungarian Meteorological Service introduced the quality management system ISO 9001:2000 in 2002 for the whole range of its activities which was quite unique among meteorological services. However, GHG inventory preparation was not among its activities in that time. Therefore, the scope of our ISO accreditation had to be modified and lots of efforts have been made to bring also the national system under the umbrella of the ISO QM system. Several regulatory ISO documents were created, among others: ISO procedure on the activities of the GHG Division; QA/QC plan; Register of used data, data sources and calculation methods; Record of data changes; Register of recalculations; Record of data quality check; In 2009 a new ISO document was introduced to enable the documentation of sector specific quality checks. This document includes a compulsory check list, summary of results of checks, suggestions for corrective actions similarly to the example given in Annex 6A of the 2006 Guidelines. The basic document is the Procedure on the activities of the GHG Division. It contains the basic principles of the inventory preparation and reporting processes, prescribes the obligation of making a QA/QC plan, and regulates the documentation and archiving activities. Our QA/QC plan, which is an audited ISO document, consists of the following elements:

- Specification of the sectoral responsibilities of the core team;
- Nomination of an officer responsible for the QA/QC system: the QA/QC coordinator;
- Documentation. All data, data sources and calculation methods need to be documented by the sectoral experts of the core team filling in an ISO form. Based on this documentation, sectoral reports are to be written about the status of the sector and possible future improvements;
- Data quality check. Besides self-checking, the entries of data providers and external experts are checked regularly which is an interactive process during the whole inventory cycle. Significant changes compared to previous data shall be explained;
- Reviews.
    - Internal ISO audits are conducted every year. The Met. Service passed an in-depth ISO audit end of January 2009. The most recent audit of the GHG Division took place in January 2011.
    - Peer-reviews will be conducted depending on available resources. Besides, there is an ongoing QA procedure between the two institutes involved in the forestry part of the inventory.
    - The recommendations of the last years' in-country review conducted by the expert review team of the UNFCCC will be taken into consideration as much as possible (see Annex 8.)

- Checking the results of the EU's internal review for the EU15, and analyze its relevance for Hungary.
- Checking the differences in activity data to increase the consistency between different emission databases, especially the GHG inventory, LRTAP inventory, ETS data, NAMEA data, and the E-PRTR data.
- Incorporation of ETS data in broader extent for revision of the used EFs and for better sectoral allocation of emissions
- Development plan. Based on the outcome of all reviews and own experience, a development plan has to be made in order to further improve the system.
- R+D projects. The Hungarian Meteorological Service funds research and development projects for the improvement of the inventory whenever possible.
- Training plan.

Having an ISO system in place has an advantage of being subject to regular internal and external audits. During our last external audit the activities of the GHG Division were audited as well. Our system was audited favorably in the end of March 2007; and our ISO certification has been renewed in January 2009. Therefore we can claim that the GHG inventory is subject to ISO 9001:2008.

Other QA/QC activities

Besides ISO requirements, other QA/QC activities are carried out, as well. For every sector of the inventory, there is a responsible person within the core team in the Met. Service. These sectoral responsibilities are laid down in the yearly QA/QC plan. Especially in case of external experts, this responsible member of our team conducts several quality checks on the provided calculations. Moreover, this exercise can be regarded as an interactive process throughout the whole inventory cycle, since the used methodologies, early results are discussed during the process of the emission/removal calculations. This QC procedure also led to a few recalculations. Many elements of the general Tier1 QC procedure are applied. The used parameters and factors, the consistency of data are checked regularly. Completeness checks are undertaken, new and previous estimates are compared every time. Data entry into the database is checked many times by a second person. If possible, activity data from different data sources are compared and thus verified. In response to our request, several data suppliers made declarations as regards quality assurance systems in place during the collection of the data. As a new element, experts involved in emission forecast consulted in many areas with inventory experts of the Hungarian Meteorological Service to reach better consistency, which in turn represented some sort of QA procedure for the inventory itself.

Nevertheless, the work continues to refine the used QA/QC procedures and implement further elements.

1.8. Uncertainty

The reliability of the data for individual source categories was estimated on the basis of the GPG but information from the industry and expert estimates was also used primarily in the key source categories. In a number of cases, the level of uncertainty was also characterized in words. Regardless of the actual values obtained, it can be generally stated – like before – that the most reliable data are those of CO_2 emissions and the least reliable ones are those of N_2O emissions.

In summary, the reliability of the inventories can be characterized as follows:

The CO_2 calculation has the highest reliability and has a weight of 75.7% in the total emission (in CO_2-eq). The least reliable is N_2O calculation representing 10.1%. CH_4, which has a medium reliability, has a similar proportion (12.6%). Fluoride gases are irrelevant here because their contribution to the total emission in only 1.6%. Accordingly, the calculated uncertainties of the emissions of different gases are as follows (more details in *Table A7-3* in the Annexes):

CO_2	3.6%
CH_4	17.3
N_2O	137.0%

On the basis of Table 6.3 of the GPG we have determined the total uncertainty according to the Tier 1 method. Accordingly, the combined uncertainty as % of total national emissions (in the year 2009) is 17.6% and the uncertainty introduced in trend in national emissions is 2.4%.

1.9. Completeness

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2009. All relevant gases, sectors and categories are included. The inventory is complete in terms of geographic coverage. The notation keys are used throughout the tables. However, some of the time-series are subject to ongoing revisions, especially in the LULUCF, cement production and wastewater categories, therefore the time-series are not fully consistent and some explanations connected to the notation keys are missing.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

In the United Nations Framework Convention on Climate Changes, Hungary undertook to keep its CO_2 emissions in 2000 at or below the 1990 level. In the Kyoto Protocol, our country committed to reducing the average greenhouse gas emission by 6% of the base year level during the five years of the first commitment period (2008 to 2012). It will be shown in the next Sections that Hungary has complied with these commitments.

2.1. Description and interpretation of emission trends for aggregated greenhouse gas emissions

The trends of the total greenhouse gas emissions may be assessed on the basis of the GWP. The table below shows the time series of net and gross emissions:

Table 2.1. *Total GHG emissions (including and excluding LULUCF)*

GREENHOUSE GAS EMISSIONS (CO_2-eq, Gg)	BY fixed	1990	1995	2000	2005	2007	2008	2009
Total (including LULUCF)	112 661	94 881	72 404	76 342	75 268	72 697	69 095	63 641
Total (excluding LULUCF)	115 397	96 830	78 186	76 706	79 489	75 385	73 028	66 660

BY=average of 1985-87 (1995 for F-gases) as fixed in 2007.

The figure below shows the net emissions from the base year until the last year assessed, taking also removals into account. The straight line in the figure indicates the reduction target.

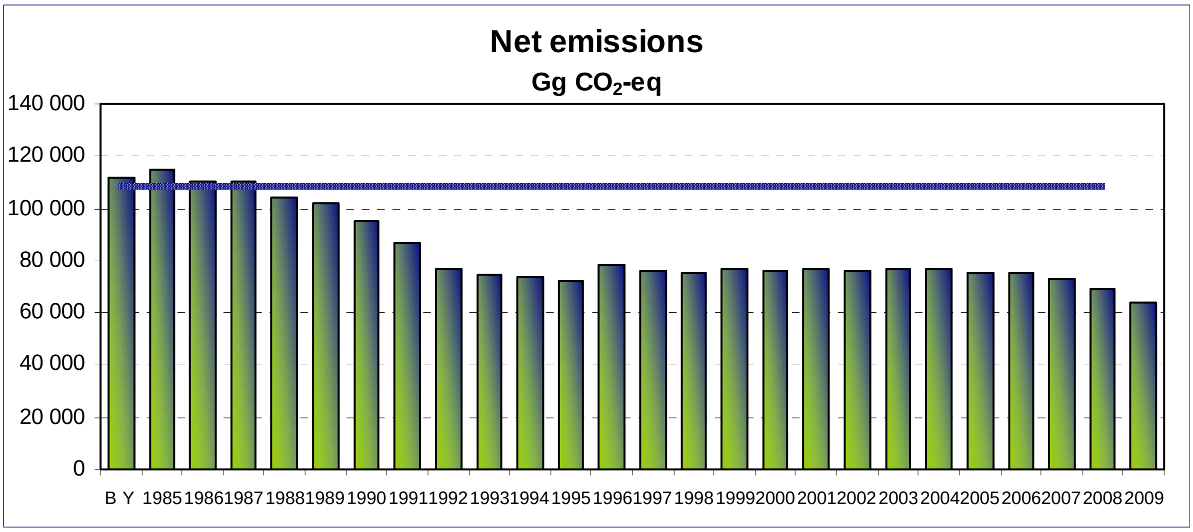


Figure 2.1. *Total emission (including net CO_2 from LULUCF) between 1985 and 2009*

Compared to the base year, emissions were significantly reduced in the energy (-39.0%), agriculture (-52.7%), and industrial processes (-61.9%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+25.7%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.
To better understand the Hungarian emission trends, the time interval of the inventory should be split into three periods with different emission relevant economic processes in the background. The first period (1985-95) would be the years of the regime change in Hungary, whereas in the second period (1995-2006) the rules of the market economy became decisive. The second period can also be characterized by the decoupling of GDP growth

from the GHG emission trend which is undoubtedly an important development. By 1999, the GDP reached the pre-1990 level; however, emission levels remained significantly below the levels of the preceding years. Thus, the emissions per GDP are decreasing.

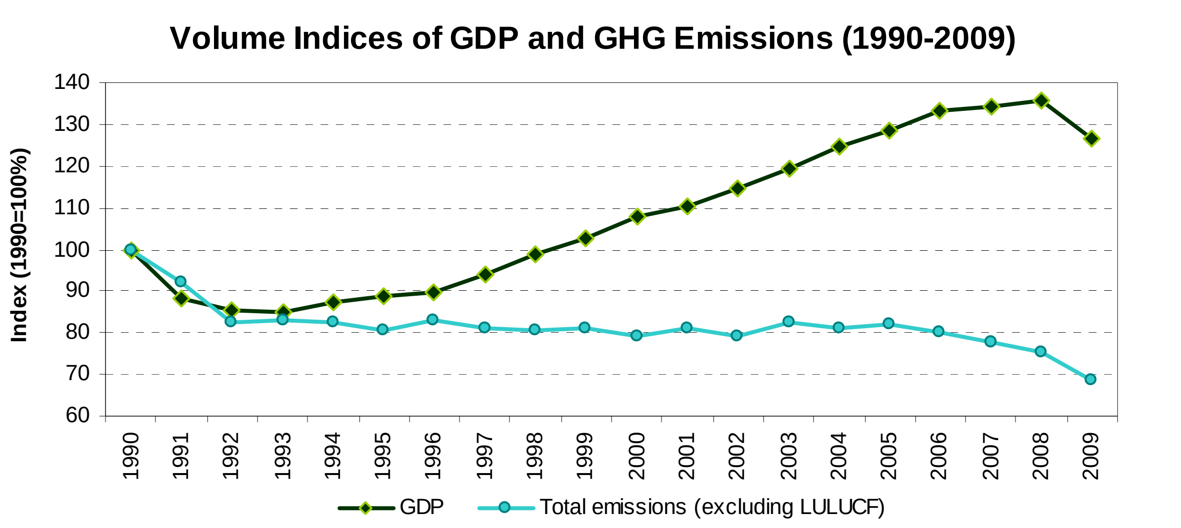


Figure 2.2. *Comparison of trends in GDP and GHG emissions*

In the third period, after 2005, Hungary experienced an emission reduction of about 16%, half of it in the first 2-3 years up to 2008: basically due to mild winters, higher energy prices, and modernization in the chemical industry. Then in 2009, the global financial-economic crisis made its radical influence felt which can also be seen at the dropping GDP values in Fig. 2.2.

Starting with the first period, the process of transition into market economy brought in its train radical and painful decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors (energy, industry and agriculture). Consequently, GHG emissions decreased substantially in these years by around 35 million tonnes CO_2 equivalent. Between the mid 80's and the mid 90's emissions fell back in the *energy* sector by around 25%, and even more, by around 50% in the *industrial processes* and *agriculture* sectors.
The most significant drop in energy use occurred in the industry especially in the energy-intensive industrial sectors (manufacture of basic metals and machinery, mining etc.). The industrial output of 1992 was two third of that of 1989. Several factories were closed down, capacity utilization was reduced, consequently the production decreased more or less drastically in each industrial sector. Some examples:

- Iron and steel production: two out of three plants were provisionally closed down;
- Aluminium: two out of three plants were closed down in 1991 (aluminium production stopped in 2006 eventually);
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed down (1988, 1991 and 1995).

The agricultural sector suffered a similar decline. As the result of the political and economic processes, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30%, the livestock by about 50%, and the use of fertilizers by more than 60%. As a consequence, the share of the agricultural sector in total GHG emissions decreased from 15.4% to 12.5%.

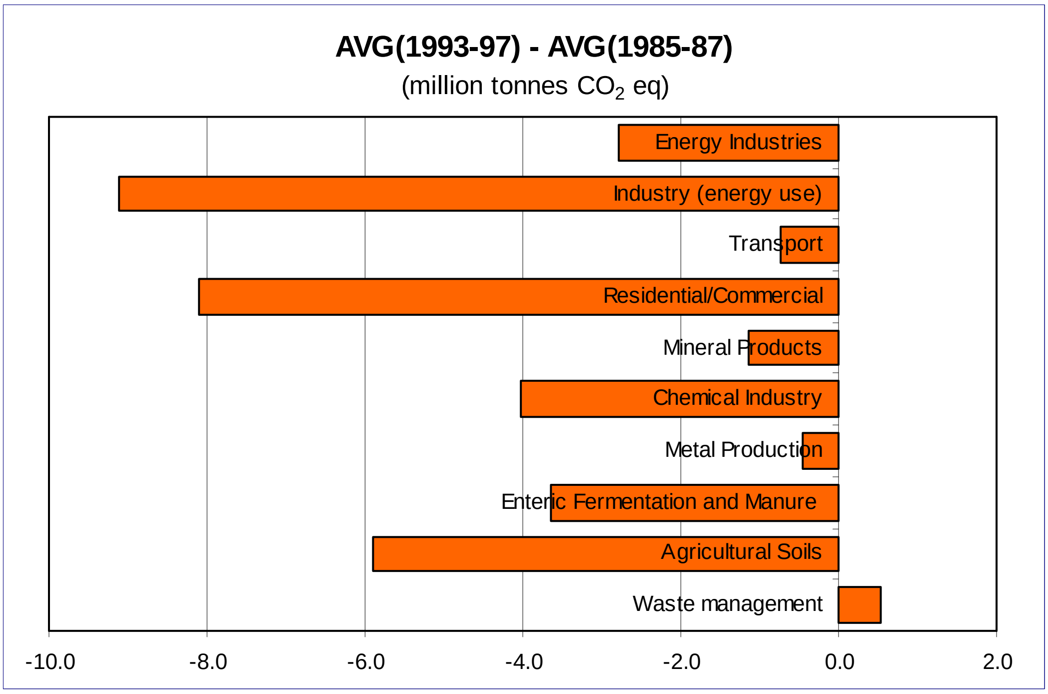


Figure 2.3. *Changes in emissions due to regime change (1985-95).*
AVG(1993-97) = average emissions of 1993-97

The small increase of emissions in the *Waste* sector is exceptional among all the sectors, and it is attributable to the slightly increasing quantities of waste generated and collected but more importantly to the applied calculation method which assumes that the degradable organic component in waste decays slowly throughout a few decades.

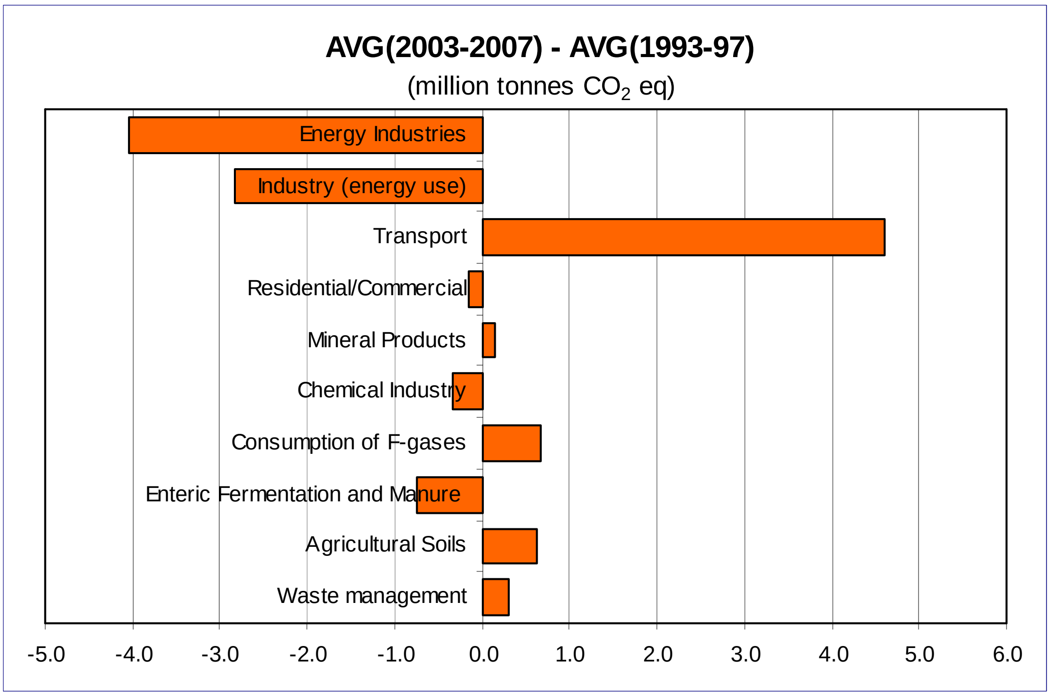


Figure 2.4. *Changes in emissions between 1995 and 2005*
AVG(2003-2007) = average emissions of 2003-2007

After the mid 90's, emissions seemed to have been stabilized around 79-80 million tonnes CO_2 equivalent. However, behind the quite stable emission level opposite processes could be observed which can be illustrated by the relatively bigger changes in the *energy sector*.

The fuel use of industry decreased further and had only a 15% share in CO_2 emissions. In contrast, emissions from transport increased significantly by more than 4 million tonnes CO_2 equivalent which represented a more than 60% growth.

In the third period, say after 2005, emissions fell by 12.8 million tonnes or 16.1%. Half of this decrease occurred between 2005 and 2008. The decreasing energy use by other sectors and manufacturing industries, and the diminishing process related emissions in the chemical industry were the main drivers of these changes. Most importantly, total fuel consumption in the residential sector decreased by almost 20% (including a 13% decrease in natural gas use) - mainly due to extreme mild winter in 2007 but probably the growing energy prices and the support for modernization of buildings might have played a role as well. Decreased production volumes and modernization in the chemical industry led to an emission reduction of about 80%. In contrast, emissions from energy industries and transport grew further.

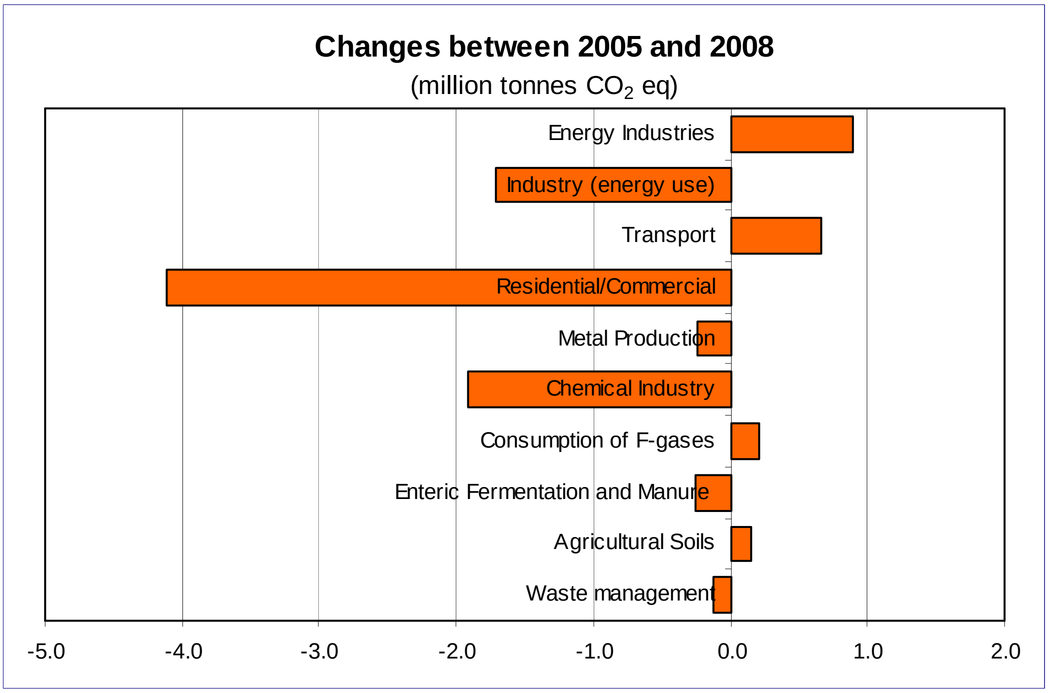


Figure 2.5. *Changes in emissions between 2005 and 2008*

Then in 2009, the Hungarian economy was hit hard by the global economic crisis that exerted a significant effect on the emission level. Emissions (excluding LULUCF) decreased by 8.7% (-6.4 million tonnes) between 2008 and 2009. In comparison with 2008, emissions in 2009 were lower in all major sectors. The highest relative reduction (-17.1%) occurred in the industrial processes sector mainly due to lower production volumes especially in mineral product manufacturing (-28.9%). Regarding absolute changes in emissions, out of the 6.4 million tonnes reduction, fuel combustion was responsible for about 4.9 million tonnes. Although the energy demand increased in the heating season due to less favorable weather conditions, the fall in the production of energy intensive sectors led to an overall decline in energy use.

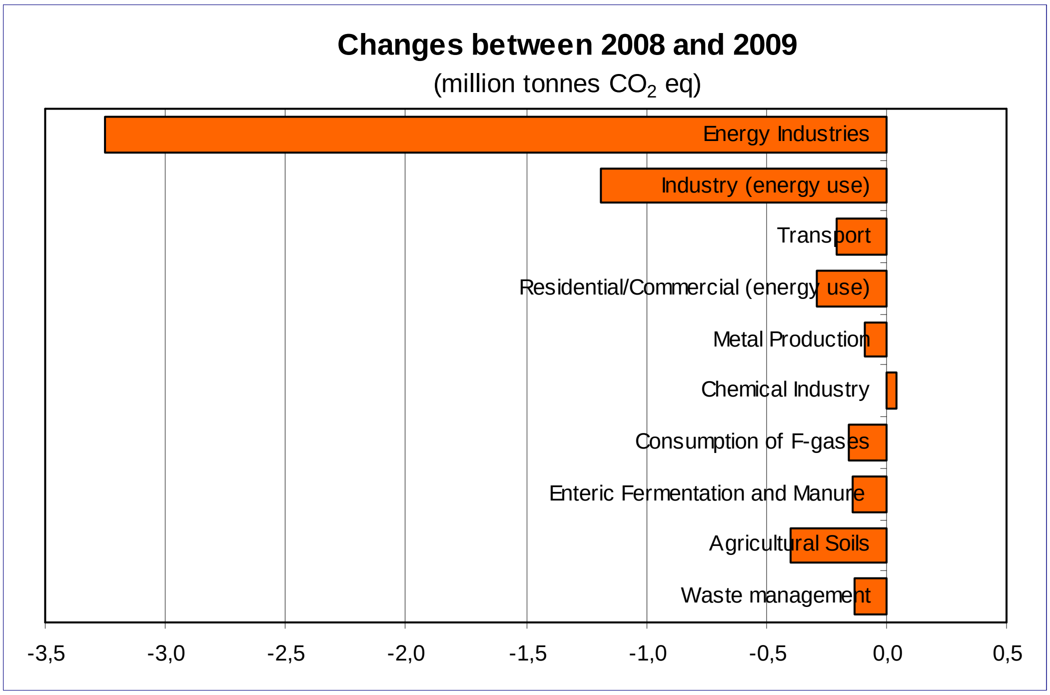


Figure 2.6. *Changes in emissions between 2008 and 2009*

2.2. Description and interpretation of emission trends by gas

The following table shows the emission data for each greenhouse gas (Gg CO_2 equivalent):

Table 2.2. *Trends in emissions of greenhouse gases in Hungary (1985-2009)*

GREENHOUSE GAS EMISSIONS (CO_2-eq, Gg)	Base year	1990	1995	2000	2005	2007	2008	2009
CO_2, without LULUCF	84,582.1	72,125.5	61,196.1	58,299.8	60,731.4	57,611.9	56,101.5	50,442.8
CH_4, without LULUCF	12,197.2	11,684.2	9,426.5	9,567.0	8,986.9	8,753.4	8,554.4	8,385.2
N_2O, without LULUCF	16,821.0	12,710.1	7,325.2	8,266.1	8,759.8	8,038.5	7,201.8	6,759.2
HFCs	0.0	NA,NO	0.7	222.0	600.3	807.6	936.1	851.3
PFCs	268.5	270.8	166.8	211.3	209.4	2.4	2.4	1.7
SF_6	81.0	39.9	70.1	140.1	201.0	171.6	231.9	219.7
Total (excluding LULUCF)	**113,949.8**	**96,830.5**	**78,185.6**	**76,706.2**	**79,488.9**	**75,385.4**	**73,028.1**	**66,659.8**

Base year=average of 1985-87

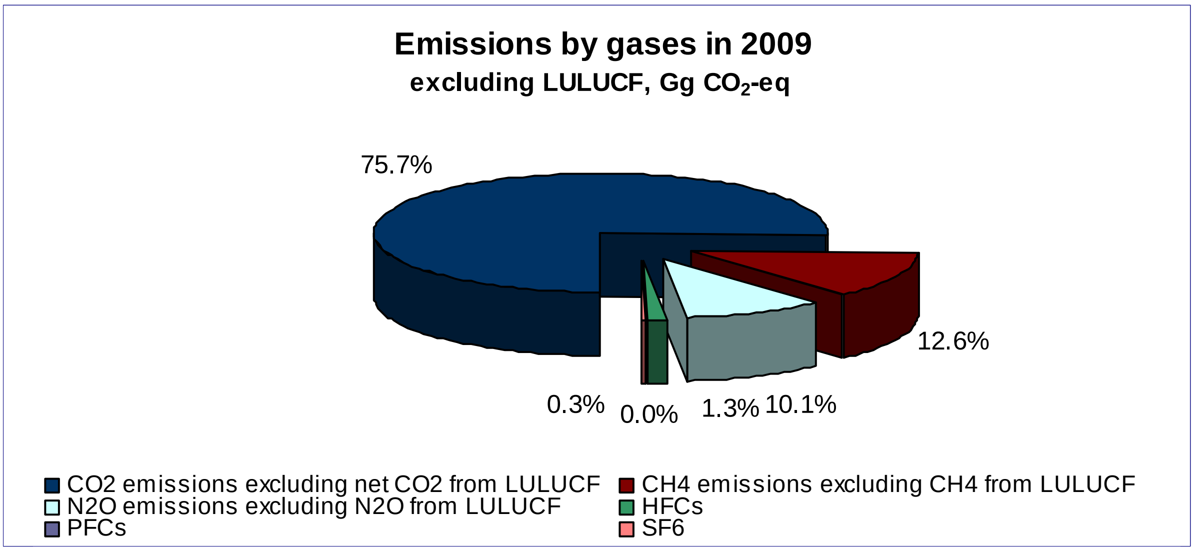


Figure 2.7. *Shares of emissions of greenhouse gases in 2009*

The drop in CO_2 emissions during the early 1990's was attributable to the reduction of fuel uses in conjunction with the national output decline. From the second half of the 1990's emissions showed stagnating or slightly decreasing tendencies reflecting the effects of restructuring following the economic growth. The changes in the fuel-mix resulted in reduction of the specific emission levels.
As regards CH_4 emissions, two opposing effects should be considered. On the one hand, reductions in the livestock resulted in lower emissions. On the other hand, fugitive emissions increased as gas supply via pipelines became more and more widespread. Besides, emissions from waste disposal have grown, at least until 2005. This is the reason why the resultant trend is relatively stagnating or slowly decreasing.
Due to the above factors, also N_2O emissions significantly decreased in the beginning of the period. Later it showed a slightly rising trend, followed by another drop primarily reflecting the fluctuations in agricultural output and the modernization of nitric-acid production.

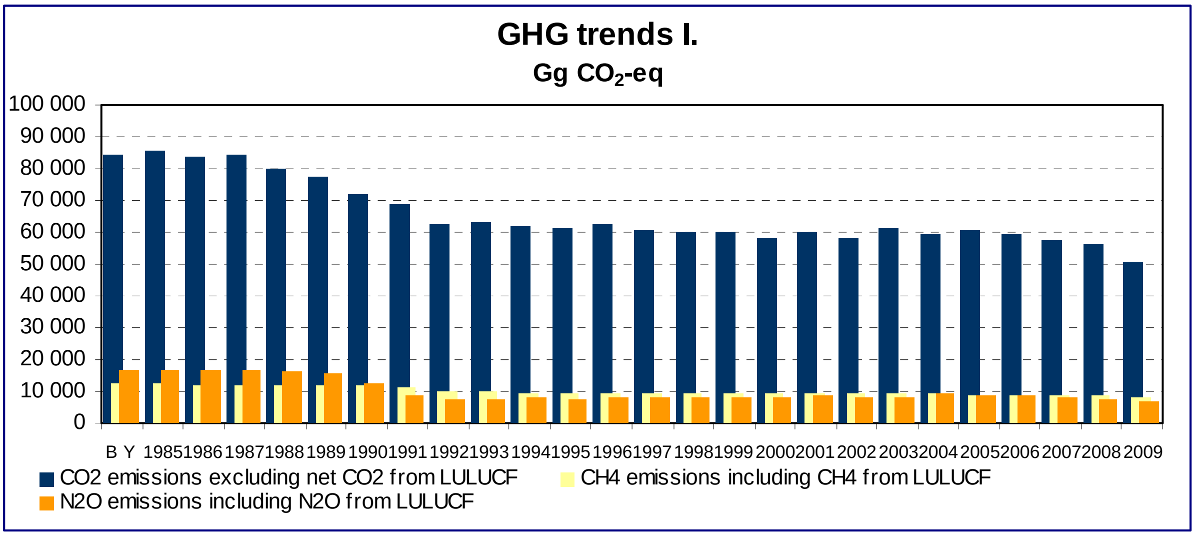


Figure 2.8. *Trend of emissions by gases*
Note: BY=average of 1985-87 but 1995 for F-gases

The use of HFC gases became more intensive in the second half of the 1990's in conjunction with the restriction of the use of chlorofluorocarbons as refrigerants. The rise of emissions is obvious, even if there was a decrease in 2009.

PFCs emissions are principally related to aluminium production processes. Therefore, the tendencies of PFC emissions reflect the changes in aluminium production. Following a drastic reduction in the beginning of the period, the levels showed a slow but steady increase. Then the aluminium production ceased suddenly in 2006.
SF_6 emissions primarily depend on the uses in the power generation industry. The tendencies vary according to the manufacturing/application needs and show an increasing trend.

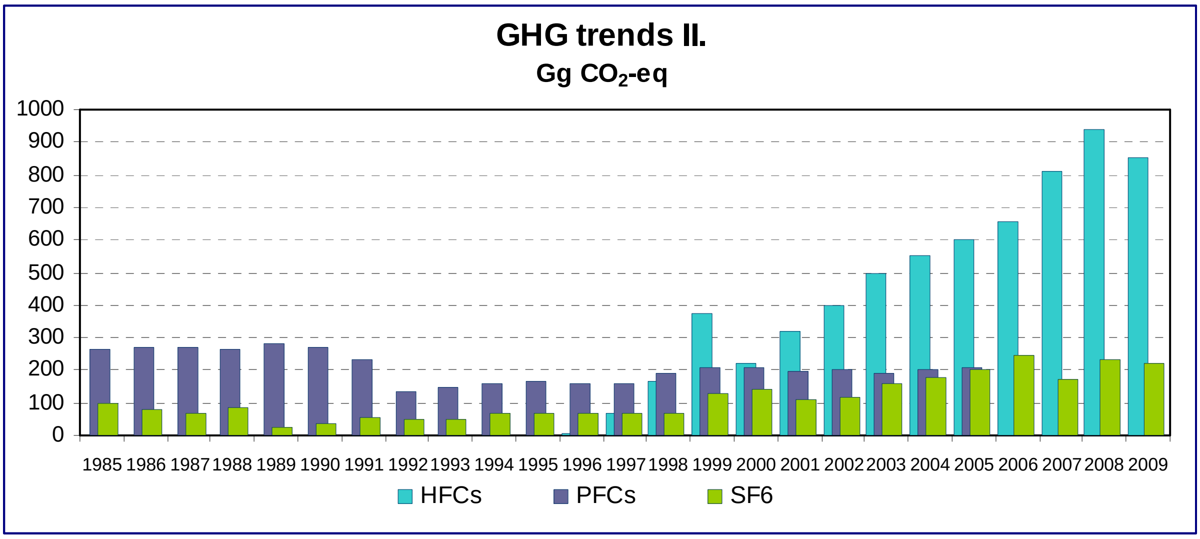


Figure 2.9. *F-gases trend (1985-2009)*
*Note: *BY=average of 1985-87 but 1995 for F-gases*

2.3. Description and interpretation of emission trends by category

The following figure shows the emissions by sources and removals by sinks for each sector. As demonstrated by the figure, Energy and Agriculture are the sectors with the greatest influence on the total emission. The biggest emitting sector was the energy sector contributing 75.1% to the total GHG emission in 2009. Agriculture was the second largest sector with 12.5% while emissions from industrial processes (with solvent and other product use) accounted for 6.8% and the waste sector contributed 5.6%. Compared to the base year, emissions were significantly reduced in the energy (-39.0%), agriculture (-52.7%), and industrial processes (-61.9%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+25.7%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.

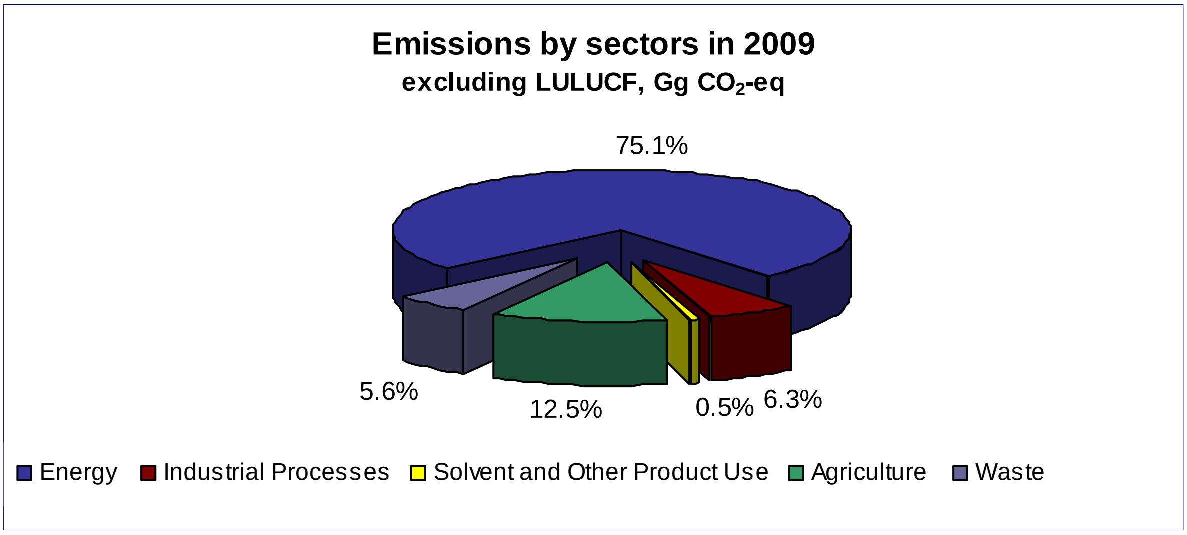


Figure 2.10. *Shares of sectors in 2009*

Emissions by the *energy sector* decreased in the first part of the period as a result of reduced energy consumption and use of fuels with more favorable composition. Between 2005 and 2008 growing emissions from energy industries and transport could be observed which were more than offset by drastic reduction of emissions by the residential sector and manufacturing industries. And then the economic crisis came…

The *energy sector* was responsible for 75.1% of total GHG emissions in 2009. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.3% to sectoral emission. Considering fuel use, gases had the highest proportion (49.6%), liquids and solids represented 28.6% and 14.0%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 6.9%. The most important subsector was energy industries with a proportion of 32.6% within the energy sector, followed by other sectors (26.9%) and transport (25.3%). Fugitive emissions from fuels played only a small role with 4.4%. The most dynamically increasing category was transport which had 63.3% higher total emission in 2009 compared to the base year.
The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation which caused sudden decrease in energy demand. Besides, ongoing changes in the fuel-structure, i.e. solid fuel as the most important source in the 80's had been replaced by natural gas, led to further decrease of total emission.
Overall emissions from the energy sector decreased by 8.8% between 2008 and 2009. Electricity production and net consumption were 5.7% lower than in 2008, share of nuclear and renewable energy further increased in 2009, therefore the lower amount and lower share of fossil fuels used for electricity and heat production resulted in 16.5% decrease in emissions from energy industries. The continuous growing tendency of transport emissions stopped after a more than 80% increase between 1995 and 2007; emissions even decreased by 1.6% in 2009. The total amount of biofuel use was nearly the same as in 2008. The tertiary sector used nearly the same amount of energy, but its emission also decreased by 2.2% due to the higher share of biomass.

In 2009, a*griculture* was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH_4 and N_2O gases: almost 85 percent of total N_2O emissions were generated in agriculture in 2009. Emissions from agriculture decreased by 52.7% over the period of 1985-2009. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 15.4% to its present share of 12.5%.

Between 1996 and 2008, agricultural emissions stagnated around 9Mt with fluctuations up to 5%. Behind this trend there were compensatory processes. While the number of livestock decreased further, leading to lower emission, the use of fertilizers increased by 67.5% until 2007 which caused growing nitrous-oxide emissions from agricultural soils. In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels.
Agricultural emissions fell by 5.9 percent between 2008 and 2009. This reduction was mainly driven by the 7.1% decrease in the emissions from agricultural soils, primarily due to the 6.5 per cent reduction of fertilizer use. Although fertilizer prices decreased during 2009, they stayed relatively high, especially at the beginning of the year, which lead to lower synthetic fertilizer use. Besides, the lower harvested production resulted in lower emissions from crop residues in agricultural soils compared to its high level in 2008. The continued decline in animal population resulted in further decrease in emissions from the Agriculture sector. Mainly the decrease in swine population caused declining methane emissions here. Although the forage prices were more favorable than in 2008, the falling profitability of swine farming in private farms resulted in an 11 percent reduction of the swine population.

The *industrial processes* sector was the third largest contributing 6.3% to total GHG emissions in 2009. (Solvent and other product use added further 0.5% to total emissions.) The most important greenhouse gas was CO_2, contributing 73.5% to total sectoral GHG emissions, followed by F-gases with 25.6%. Within this sector, 38.5% of the emissions came from mineral products, followed by 25.6% from consumption of halocarbons and SF_6 and 20.4% from non-energy use of fuels. Process related industrial emissions decreased by 61.9% between base year and 2009, and by 40.7% between 2005 and 2009.
The key driver of the 17.1% (-0.9 Mt) reduction between 2008 and 2009 was the mineral production. Cement production decreased by 23%, lime production by 35%, whereas the drop in ceramics and brick production was not less than 79%! The relatively smaller (15%) increase in ammonia and nitric-acid production went against the general trend in the industrial processes sector.
Although emissions of F-gases represent only 1.6% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission increased tenfold. Nevertheless, also emissions from consumption of F-gases decreased between 2008 and 2009.

The *waste sector* represented 5.6% of total national GHG emissions in 2009. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+25.7%). However, the growth of emissions seemed to be stopping in recent years, moreover a reduction of 5.6% could be observed between 2005 and 2009. In all the years, the largest category was solid waste disposal on land, representing 80.1% in 2009, followed by wastewater handling (18.0%) and waste incineration (1.9%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade.

In the *Land Use Land-Use Change and Forestry* sector, using the currently available data, carbon uptake of the forests living biomass, non-CO_2 emissions from burning of slash on-site, and for the last couple of years, forest wildfires are reported. Overall, the sector is a sink of carbon because of the huge amount of carbon uptake of forests, due to continuous afforestation efforts and sustainable forest management. In the inventory period, the forest area increased by 350,000 hectares, and the amount of the current annual increment exceeded the annual harvest in all years. The complex dynamics of the land use and land-use changes lead to highly fluctuating estimates of sectoral removals. Our estimates indicate an average annual 2.9 million tonnes removal, CO_2-eq. net removals range from 0.09 million tonnes in 1985 to 5.8 million tonnes CO_2 in 1995. In 2009 the LULUCF sector accounted for

3.0 million tonnes carbon-dioxide removals. The removals of forests amounted to 3.2 million tonnes, while the living biomass of orchards and vineyards were a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. In 2009 the emission of the living biomass of vineyards and orchards accounted for 0.25 million tonnes CO_2.
Our mineral soils used for agricultural purposes remove a small amount of carbon (0.22 Mt in 2009), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favourable processes that increase the soil carbon content.
As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.1 million tonnes CO_2-eq. mainly due to afforestation and reforestation in 2009. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 1.9 million tonnes CO_2-eq.

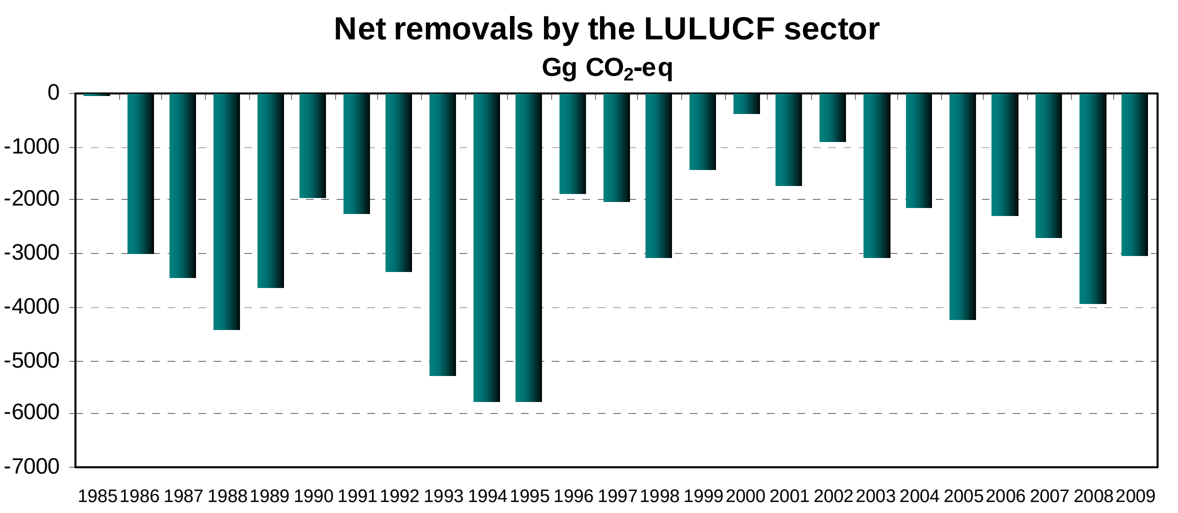


Figure 2.11. *Sinks of LULUCF*

2.4. Trends of indirect gases and SO_2

Indirect gas emissions have been calculated in the national emission database (NED) for several decades and also in the CORINAIR for more than ten years. Since 1998, the CRF database has been loaded with data in line with these. Due to capacity problems, the CRF spreadsheets prepared for the preceding years had not been loaded with data for indirect gases as such data were otherwise available. Emission data for these gases are as follows (kt):

Table 2.3. *Trends in emissions of indirect greenhouse gases and SO_2. The database are not complete for the beginning of the period.*

	1985	*1990*	2000	2003	2005	2006	2007	2008	2009
NO_X, Gg	*262.5*	*238*	185.08	210.70	203.15	202.44	185.43	168.76	154.20
CO, Gg	*931.1*	*997*	592.66	599.82	588.20	594.31	576.70	570.34	544.91
NMVOC, Gg	*232*	*205*	166.01	169.01	176.23	186.71	167.68	168.40	133.79
SO_2, Gg	*1403.6*	*1010*	488.96	347.83	146.65	123.11	98.59	106.73	89.37

The significant reduction in sulphur dioxide is attributable to the reduction in fossil fuel uses, as well as to the decreasing sulphur content of these fuels. The further decrease in 2000 was caused by the introduction of SO_2 precipitators in carbon-fuelled power stations. The decrease in carbon monoxide is the result of the reduction in the quantities of fuels used, as well as that of factory closings and technology changes in the preceding years. NO_X and NMVOC emissions show no significant trend in the last 15 years.

3. ENERGY (CRF sector 1)

3.1. Overview of sector

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2, T3
Emission factors: D, CS, OTH, PS

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources. *Figure 3.1* shows the emission trends in the sector by gases.

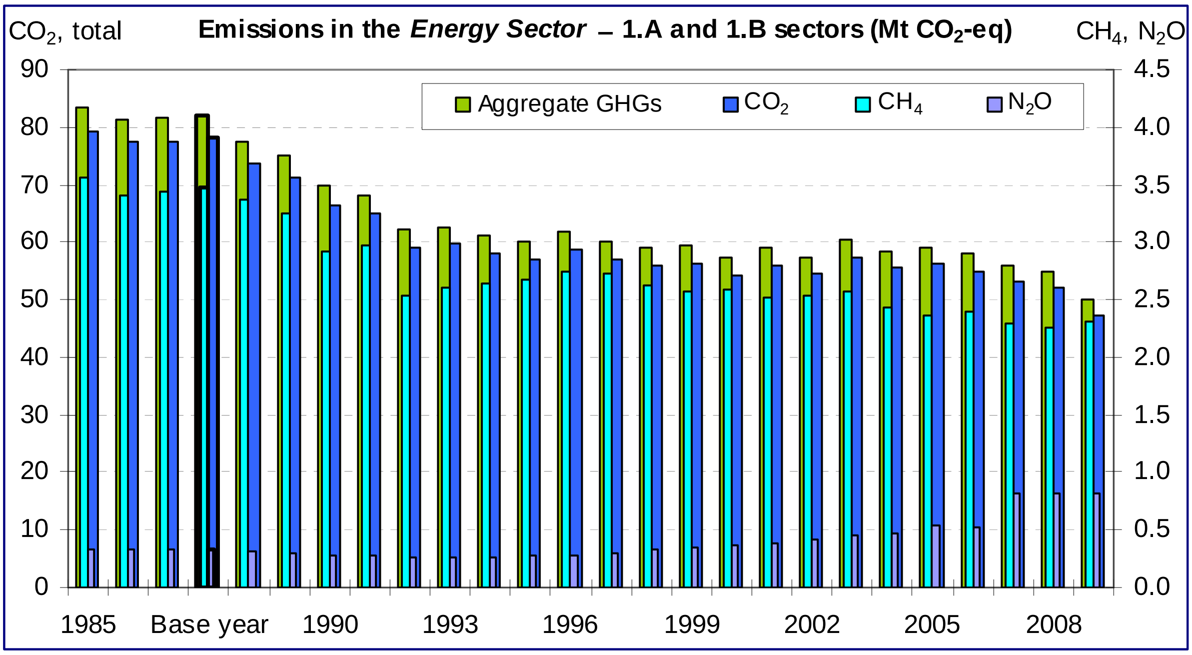


Figure 3.1. *CO_2, CH_4 and N_2O emissions in the Energy Sector (1985-2009)*

The principal driver of emissions in this sector is the fuel consumption. *Figure 3.2* represents the proportion of combusted fuel types in the base year and 2009.

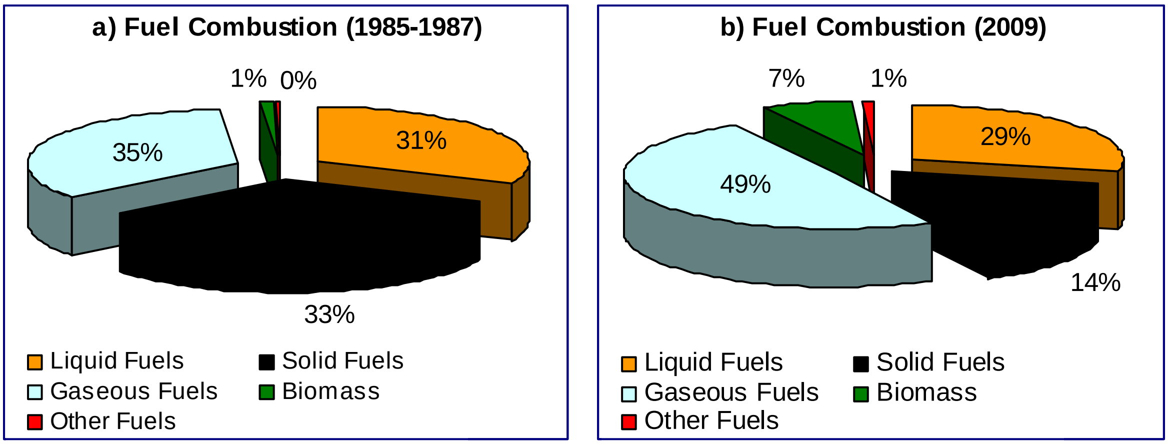
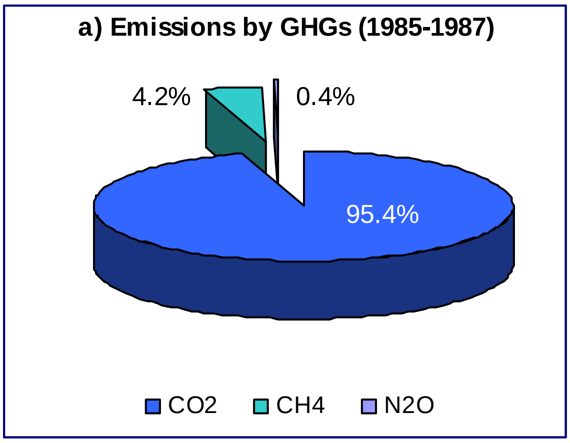


Figure 3.2. *Fuel combustion in the base year (a) and 2009 (b)*

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.3% to sectoral emission, followed by CH_4 with 4.6% and by N_2O with 1.0%. Among fuels, gases have the highest proportion (43%), liquids and solid have less (33% and 22%) and other fuels (waste) have the lowest representing 1% of the sectoral GHG emissions. Besides the sudden decrease in energy demand in the years of economic transformation, also the changes in the fuel-structure in the '90s, when the most important source of the base years, namely solid fuel has been replaced by natural gas, led to decreased total emission. In the last 3-4 years, Hungary experienced another emission reduction of about 9% in the energy sector basically due to mild winters and higher energy prices. In 2009 also the global economic crisis affected the emissions especially in the energy and manufacturing industries sectors.



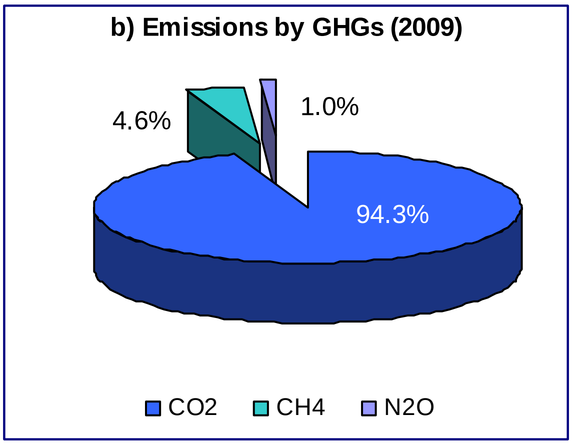


Figure 3.3. *Distribution of emission of GHGs in the Energy Sector in the base year (a) and 2009 (b)*

As regards methane emission, this sector represents 3.6% (with LULUCF) of the total greenhouse gas emission. Primarily, this results from fugitive emissions associated with conventional oil and gas production and processing (which also includes fugitive emissions from natural gas transmission). Among methane emitters, this sector's proportion is 27.5%, which represents the third highest emission compared to other sectors *(Figure 3.4.)*.

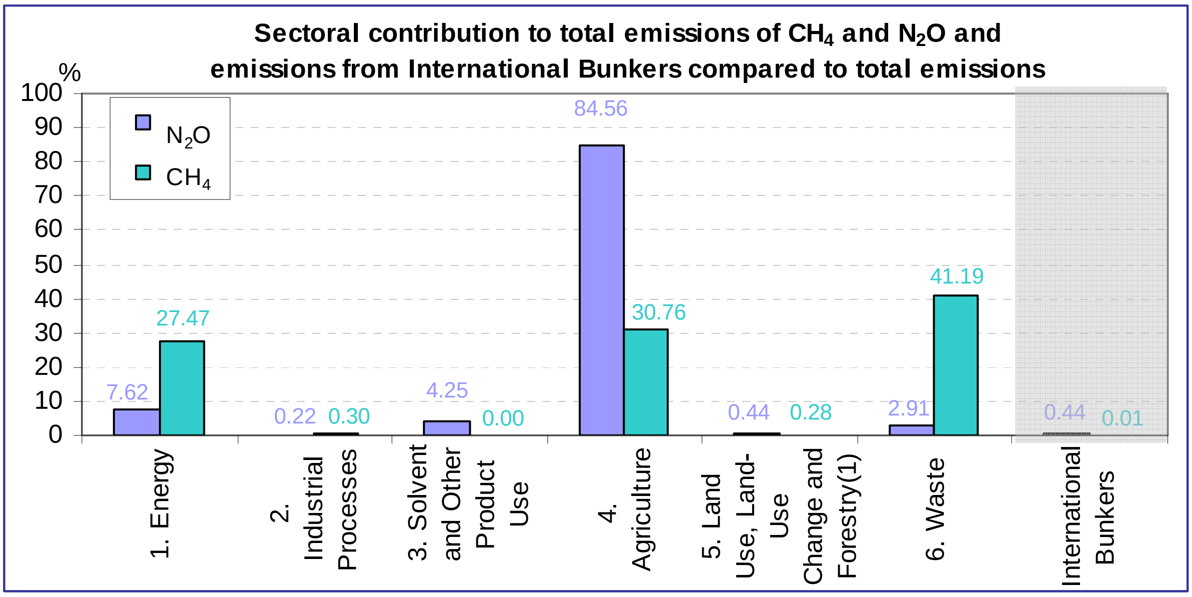


Figure 3.4. *Sectoral contribution to total emission of CH_4 and N_2O in 2009*

As regards nitrous oxide emission, this sector represents 0.8% (with LULUCF) of the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 7.6%, which represents the second highest emission compared to other sectors *(Figure 3.4)*.

Emissions of the sector strongly depends on amount of combusted fuel. *Figure 3.5*/a) illustrates the share of energy consumption among subsectors in this sector, while *Figure 3.5*/b) shows the subsectoral proportion of the total GHG emissions in the *Energy Sector*. The most important subsector of the *Energy Sector* is the *Energy Industries* (1.AA.1) with a proportion of 33%, followed by *Other Sectors* (1.AA.4) and *Transport* (1.AA.3) representing 27 and 25% of the total emissions in this sector, respectively. Similarly to the previous year the least contribution to the emission from fuel combustion has *Manufacturing Industries and Construction Sector* (1.AA.2) with 11%. *Fugitive Emissions from Fuels* (1.B) play only a small role in emissions of the sector with 4%.

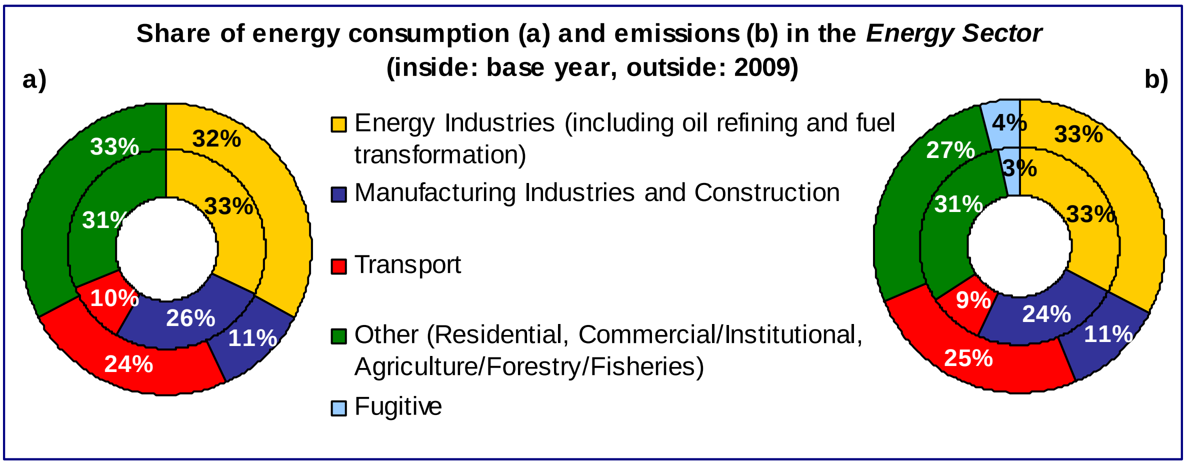


Figure 3.5. *Proportions of energy consumption and emissions in the Energy Sector in the base year and 2009*

Calculation of greenhouse gas emissions from combustion is based on the amount of fuel used. This was calculated using the energy balance of Hungary (summary table: see *Annex 2*), the fuel balance for each fuel type and the fuel consumption for each subsector prepared by the Energy Centre – Energy Efficiency, Environment and Energy Information Agency Non-Profit Company. The energy statistics has a chapter about the energy carries balances by branches. Nowadays, division into branches follows the structure of NACE Rev.2 (see *Annex 2*). Detailed EU-conform statistics from industrial and energy industrial activity help to compile the *sectoral approach*. Before 1998, some IPCC categories could be found only in aggregation with similar branches in the statistics, therefore the Hungarian inventory still follows this tradition in case of manufacturing metal products (IPCC 1.AA.2.A and 1.AA.2.B are included under 1.AA.2.A) to keep consistent time-series. Non-energy use of fuels and fuel used for transportation are included in the consumption of branches, therefore tables of fuels related with the mentioned activities cannot be adopted completely in their original form. Tables from the different transportation forms and non-energy use of fuels as well as personal communication with the statistics' provider allow to fill in the CRF tables according to the guidelines.
In the Energy Statistics Yearbooks, the quantities of fuels are expressed in calorific values (see *Annex 2, Table A2-6*). Therefore, these were directly used for the emission calculations and the values of the conversion factors are globally 1.0 in all of the categories.
Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary, Energy Statistics, the Hungarian Oil and Gas Company Plc. (MOL) and from the Hungarian Energy Office.
LPG and petroleum coke was taken into account as liquid fuels having significant influence on the IEF value of this fuel type.

3.2. Fuel combustion (CRF sector 1.A)

3.2.1. Comparison of the sectoral approach with the reference approach

The quantity of CO_2 from energy consumption was determined on national level (*reference approach*) and on sectoral level (*sectoral approach*) as well.
The *reference approach* (RA) is based on national energy balance: production, import, export, stock changes, and international bunkers. It is necessary to use calorific values to harmonize information across all fuels. In our case, the apparent consumption of the energy balance components mentioned is already given in calorific value in the national energy statistics. Sectoral approach allocates the emissions by source category and includes only the combusted amount of fuels.
The *reference approach* was compared with the *sectoral approach* as a check of combustion-related emissions. The check was performed for all years from 1985 to 2009 and is an integral part of reporting to the UNFCCC. The analysis includes also the comparison from the base year (1985-87).
The *reference approach*, in theory, includes all CO_2 emissions from all fossil fuel uses in a country and should be compared with a set of emissions from the *sectoral approach* that includes all CO_2 emissions from energy use of fossil fuels.
Emissions from feedstocks and non-energy use of fuels are taken into account in the Industrial Processes sector (2B and 2G) in case of *sectoral approach* (SA), therefore the energy and carbon content of these fuels are removed from the RA (the fraction of carbon stored is 1 for all these fuels in the 1D sector), too. Carbon content of fugitive emissions like flaring during oil refining process or distribution loss of natural gas are also removed from the RA because these emissions are allocated in the 1B sector.
In the CRF reporting software, the RA is directly compared with the sectoral fuel combustion total. This direct comparison of the energy outputs from the RA and the SA used in the Common Reporting Format (CRF) shows that the total fuel consumptions of the RA are consistently larger than the SA totals (*Figure 3.6*). The remaining differences – after extracting the feedstock and non-energy use of fuels, and fugitive emissions – are the transformation losses which are occurring during coking, briquetting or oil refining.

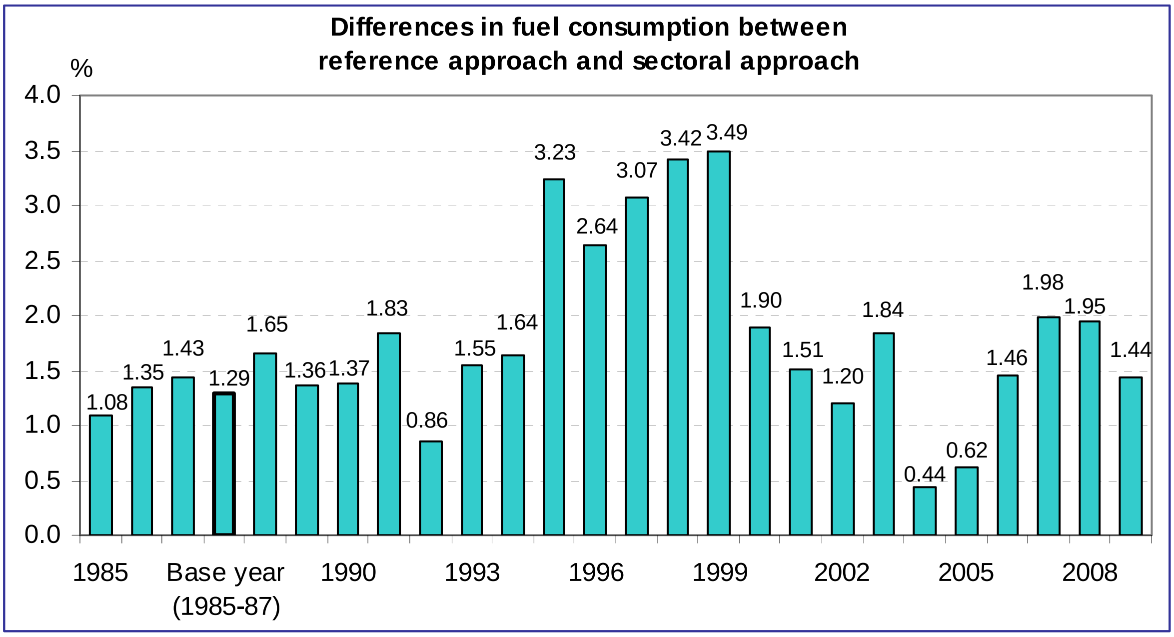


Figure 3.6. *Comparison of sectoral and reference approach – fuel consumption*

In 2009, comparing the two approaches the difference was 1.44% in energy consumption (*Figure 3.6*) and 1.33% as regards CO_2 emission (*Figure 3.7*). The range of differences are between 0.44% (2004) and 3.49% (1999) with a 1.75% mean value as regards the fuel consumptions, and -0.04 % (2004) and 3.48 (1999) with a 1.61% mean value as regards the CO_2 emissions. Since the time-series in case of SA is not consistent for coke oven gas, and also the fugitive emissions in the RA were taken into account only after 2005, the time-series of differences will be changed in future submissions and it may be more uniform.

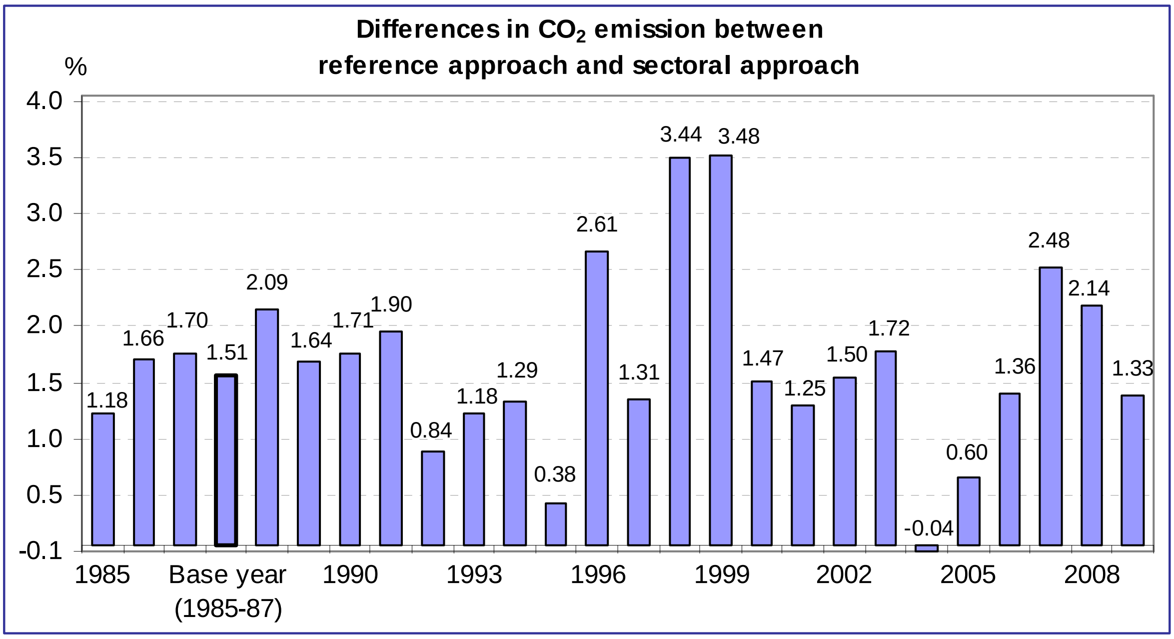


Figure 3.7. *Comparison of sectoral and reference approach – CO_2 emission*

3.2.2. International bunker fuels

In accordance with the Revised 1996 Guidelines, emissions from international aviation were included under the category *International Bunkers* on the basis of the quantities of kerosene used. In the time-series of the resulting CO_2 emission, significant jumps are present at certain places, which are obviously due to the changes in kerosene consumption because the same default EF was used throughout the entire time series. Naturally, changes in kerosene consumption reflect the travelling/transport needs. This is clearly illustrated in *Table 3.1*, which shows the air travelling/transport performance of the past years.

Air transport	2000	2003	2004	2005	2006	2007	2008	2009
Passengers carried (thousands)	2,476	2,719	3,193	3,785	4,551	4,896	4,340	4,573
Transported quantity of goods (kt)	22	13	19	16	16	17	14	16
Quantity of kerosene (TJ)	8,957	8,358	8,610	9,368	9,210	10,145	11,303	10,584

Table 3.1. *Air travelling and transport performance in Hungary since 2000 in selected years (Source: HCSO, 2010; Energy Centre, 2010)*

Emissions from in-country aviation, which represent a very low proportion, were taken equal to the emissions from consumption of aviation gasoline, and calculated in those years when the related data were available in the energy balance. Where aviation gasoline was not indicated in a separate line, consumption and emissions are calculated together with road traffic gasoline.

Consumption in international navigation was not considered, because separate data on the uses for international navigation are not included in the national statistics.
International navigation depends not only on geographical and economic but on political conditions, too. International conflicts, wars have significant impact on international navigation, which could be seen in Hungary during and after the war in Yugoslavia. The war set back the navigation on the Danube South to Hungary, and decreased the trade in Hungary, too. In the last years the sea navigation (there was only tramp navigation) has relapsed due to falling into disuse of ship-fleet. This process could be traced back to the absence of Hungarian harbour on seas and Danube-sea ships. Between 1990 and 2000 the role of transportation of goods on waterways decreased from 28.2% to 2.9% among goods transportation in other ways. (Source: webpage of Központi Közlekedési Felügyelet)

3.2.3. Feedstocks and non-energy use of fuels

Since the 2010 submissions, feedstocks and non-energy use of liquid fuels have been removed from the sectoral approach for the entire time-series, the CO_2 emission originated from non-combustion can be found in the *Industrial Processes Sector*. Feedstocks in chemical industry and non-energy uses have been considered in connection with sectors presented in *Table 3.2.*
The amount of fuels used is normally the same or nearly the same as the values published by IEA, because Energy Centre prepares the database for IEA, too. In case of liquid fuels, differences may be present because certain minor items in the inventory, such as white spirits, paraffins etc. are included under *other oils*. It should be emphasized that these poolings have no significant effects on the emission calculations.

Fuel type	Allocated under the sector…	IPCC code
Natural gas	Industrial processes – Ammonia and carbon black production	2.
Naphtha	Industrial processes – Feedstock and non-energy use of fuels	2.G
Bitumen	Industrial processes – Asphalt roofing, Road paving with asphalt	2.A.5-6
Gas/Diesel Oil	Industrial processes – Feedstock and non-energy use of fuels	2.G
LPG	Industrial processes – Feedstock and non-energy use of fuels	2.G
Other oils	Industrial processes – Feedstock and non-energy use of fuels	2.G
Coal (lignite)	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7
Petroleum coke	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7

Table 3.2. *Allocation of feedstocks and non-energy use of fuels*

Two new categories were added to feedstocks in 2008 submission, since emissions of these fuels are calculated in the *Industrial Processes Sector* using the EU ETS database of manufacturing bricks and ceramics. Coal and petroleum coke serve as additives increasing the porosity of bricks.
Coal oils and tars from coking coal is included with default factor for carbon stored in the 1.AD sector in this submission for 2008-2009.
Carbon content of all fuels which are allocated under the Industrial Processes sector is taken

as stored carbon in the 1.AD sector (and in the *reference approach*), however the default factor of carbon stored (*Table 3.3*) is used in the appropriate industrial processes sector for the calculation of CO_2 emissions.

Fuel type	Fraction of carbon stored (default IPCC)
Naphtha	0.8
Gas/Diesel Oil	0.5
LPG	0.8
Other oils	lubricants: 0.5 other: 0.8

Table 3.3. *Fraction of carbon stored used for the calculation of emissions from feedstock and non-energy use of fuels in the Industrial Processes sector (2G).*

3.2.4. CO_2 capture from flue gases and subsequent CO_2 storage

There are no activities in these categories.

3.2.5. Country-specific issues

Country-specific issues are included under the source category descriptions and methodological chapter of each categories.

3.2.6. Energy Industry (CRF sector 1.AA.1.)

3.2.6.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2, T3
Emission factors: D, CS, PS
Key source: Level and Trend: Public electricity and heat production, CO_2; Petroleum refining, CO_2

This subsector includes facilities generating electricity, district heating stations, oil refineries and coking and briquetting plants. On an overall level, here are the largest energy consumers. In 2009, 32% of the domestic energy consumption, of which 89% was fossil fuel, was used by energy industries (see *Figure 3.5*).

Emissions in the *Energy Industries Sector*

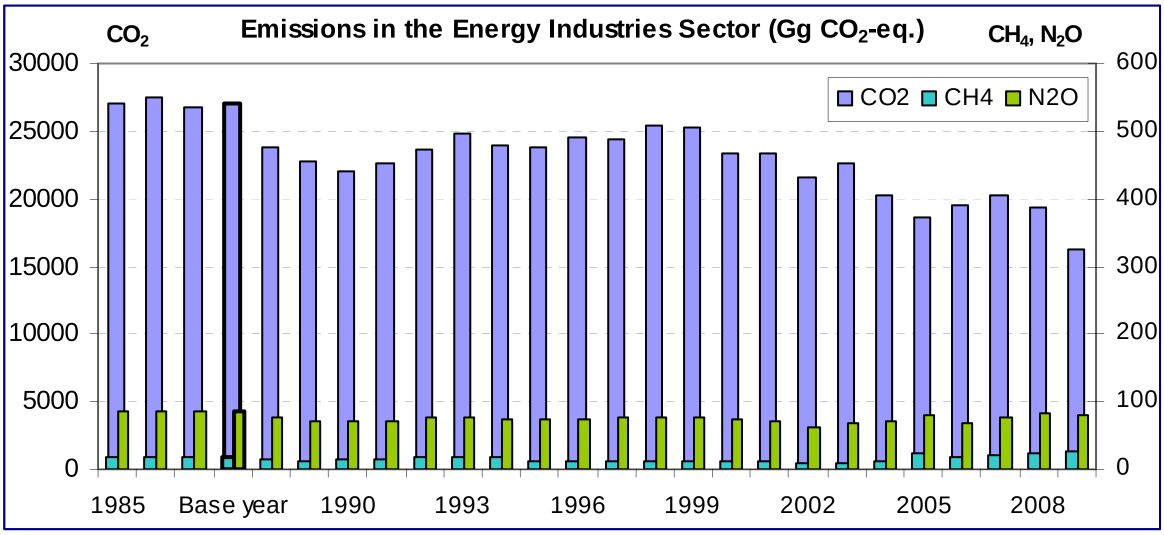


Figure 3.8. *Trends of CO_2, CH_4 and N_2O emissions in the Energy Industries (1985-2009)*

3.2.6.2. Methodological issues

Activity data

Energy consumption data were taken from the energy balance (1985-2009) of the Energy Statistics Yearbooks prepared by the Energy Centre. Besides, waste statistics and ETS data were taken into account.

The Hungarian coal terminology slightly differs from that of the IPCC. The partitioning is created according to the age of coal; *Table 3.4* shows the classification according to the Hungarian and IPCC categories. The Energy Statistics Yearbook deals with anthracite, hard coal, brown coal and lignite in the fuel balance, while the sectoral energy consumption for coal is the aggregate of hard coal, brown coal, lignite, gas coal and coking coal. In the latter case it is necessary to use additional information, from e.g. statistical yearbooks (HCSO, 1985-2009) or annual coal questionnaires (1990-2009) prepared for IEA by Energy Centre, for the distribution of the use of each coal type.

Hungarian Terminology	Net Calorific Values	IPCC Category (Gross calorific value)
Hard Coal	17-33 MJ/kg	Other Bituminous Coal (>23.865 MJ/kg)
Hard Coal	17-33 MJ/kg	Sub-Bituminous Coal (17.435 MJ/kg -23.865 MJ/kg)
Brown Coal	10-17 MJ/kg	Lignite (<17.435 MJ/kg)
Lignite (young brown coal)	3.5-10 MJ/kg	Lignite (<17.435 MJ/kg)
Gas Coal and Coking Coal		Coking Coal

Table 3.4. *Comparison of Hungarian and IPCC coal terminology (Source: Bihari, 1998; IPCC, 2006)*

In the Energy Statistics Yearbooks, the quantities of fuels are expressed in calorific values (see *Annex 2, Table A2-4*). Therefore, these were directly used for the emission calculations and the values of the conversion factors are globally 1.0 in all of the categories.

Figure 3.9. shows the changes in fuel consumption in the *Energy Industries Sector*.

The total fuel consumption shows a slight decrease till 2005 after the second peak in 1998, along with a strong fluctuation. Within this, the consumption of liquid and solid fuels has decreased significantly. In contrast, the consumption of natural gas has increased to a slight extent. The biomass use due to burning and the so-called co-burning in power plants has became more and more important and exceeds in amount the liquid fuel use in 2005. In 2006 the greatest power plant of Hungary reduced biomass-use, because the amount of obligatory purchased electricity was less than in 2005, this is illustrated on Figure 3.9. In 2007 the produced electricity increased by more than 11%, in parallel the fuel consumption (mainly natural gas) increased only by 9%, because the efficiency of natural gas combustion is better than that of the others. Biomass burning in power plants became again popular on favorable terms, which was induced by the EU carbon trading. In 2008, the produced electricity from fossil fuels and also the fossil fuel consumption of this sector decreased again, but the total generated electricity – including nuclear, waste and renewable sources – was a bit higher than in the previous year (MVM, 2009). In 2009, the electricity generation in Hungary was by 10.3% less than in 2008. The generation decrease of power plants of 50 MW and higher capacity was 11.6% while it was 2.8% in case of small power plants. The fuel-mix also changed in 2009: coal and natural gas consumption decreased, however liquid fuel use increased, but its contribution to total fuel consumption is very low. Use of nuclear, waste and renewable sources continued to increase. (MAVIR, 2010) The fuel consumption of oil refining has been quite uniform with a very moderate decreasing since 2005, but its ehavior does not affect the whole tendency of the sector, because the contribution of its fuel consumption and GHG emissions is less than 10%.

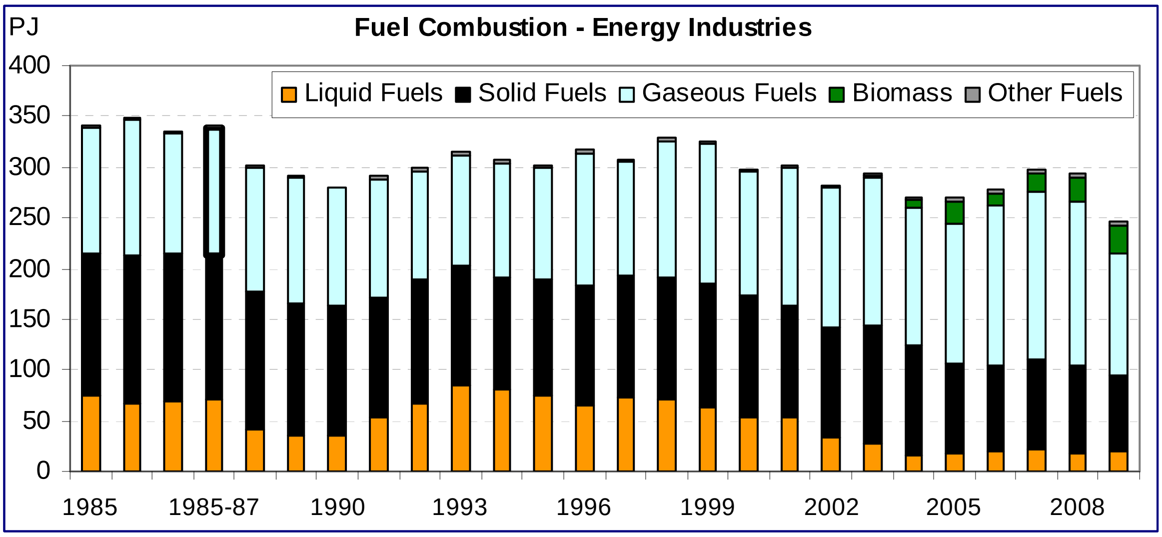


Figure 3.9. *Fuel combustion in the Energy Industries Sector (1985-2009)*

Emission factors

Carbon dioxide emissions were calculated in accordance with the Revised 1996 Guidelines in both the *Reference* and the *Sectoral Approach*. The values of the different factors were taken into consideration on the basis of the handbook, as follows: in most cases the emission factors were taken from the Revised 1996 Guidelines, as they can be found in *Table 3.5.*.

Fuel type	Emission factor (CO_2 t/TJ)	Oxidation factor
Coking coal	94.6	0.98
Other Bituminous Coal	***92.49***	***0.95***
Lignite (brown coal + lignite)	***109.69***	***0.975***
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Coke Oven Gas	***46.13***	***0.995***
Crude Oil	73.34	0.99
NGL	63.07	0.99
Gasoline	69.3	0.99
Jet Kerosene	71.5	0.99
Gas/Diesel Oil	***79.08***	***0.99***
Residual Fuel Oil	***76.85***	***0.99***
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	98.08	0.99
Other Oil	***80.31***	***1.00***
Natural Gas	56.1	0.995
Biomass (Solid and Gaseous)	109.63	0.99
Waste	***55.71****	***1.00***

Table 3.5. *CO_2 emission factors used in energy industry in the 2009 inventory year (Source: Revised 1996 Guidelines (IPCC, 1997); in bold and italics – EU ETS database of Hungary see Annex 2.4)*

**For waste only IEF is reported in summary the table, because the emission was calculated from country-specific waste amount and component data taken from Waste Information System database and the emission factors were calculated using the default or measured (from EU ETS) carbon content and fossil carbon fraction data from Table 2.4 – 2.6 in the 2006 Guidelines.*

Detailed description of country and plant specific CO_2 emission factors can be found in *Annex 2*. It should be noted that only those measured factors were applied where the EU ETS covers all or most of the installation of the sector. Default emission factors for methane and nitrous oxide have been used in the case of liquid fuels since last year. Country specific N_2O emission factor for solid fuels was changed to default value from 2006 IPCC Guidelines. The following values were used for the calculations:

Special Emission Factors (kg/TJ)	Power station		District heating station		Petroleum refining	
Fuel type	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Coal	1.25 3)	1.50 2)	1.25 3)	1.50 2)	–	–
Natural Gas	1.00 1)	0.1 1)	1.00 1)	0.1 1)	1.00 2)	0.10 2)
Residual Fuel oil	3.00 2)	0.60 2)	3.00 2)	0.60 2)	3.00 2)	0.60 2)
Gas/Diesel Oil	3.00 2)	0.60 2)	3.00 2)	0.60 2)	3.00 2)	0.60 2)
LPG	–	–	–	–	1.00 2)	0.10 2)
Firewood	30.00 1)	4.00 1)	–	–	–	–

Table 3.6. *Special emission factors for methane and nitrous oxide in energy industry*
Source: 1) Revised 1996 Guidelines (IPCC, 1997) and 2006 IPCC Guidelines
2) 2006 IPCC Guidelines
3) expert judgement based on technology and range of the EF values of international publications (Tajthy, 1994)

In 2003, wood-firing was introduced in the energy industry. Emission factors were taken from the Revised 1996 Guidelines (IPCC, 1997).

As recommended by the ERT and required by the guidelines, emissions from waste incineration for energy purposes has been re-allocated from the waste sector to the energy sector. However, emissions estimation in the energy sector is somewhat different from the methodology used in the waste incineration category. Activity data in this source category are expressed in energy consumption units (TJ) whereas in the waste sector mass of waste serves as basis of calculations. For our calculations three main activity data sources were used: data from the Waste Incineration Works (FKF) of Budapest (1985-2009), the Hungarian Waste Management Information System (2004-2009) and the ETS data (2006-2009). The Hungarian Waste Management Information System comprises facility level data on mass and composition of waste in line with the European Waste Catalogue (EWC codes) but also on waste management methods in accordance with the Waste Framework Directive. The latter made it possible to distinguish between waste incineration on land (D10) and use of waste principally as a fuel or other means to generate energy (R1).
To convert mass of waste to energy, the following conversion factors were used:

EWC codes/type of waste	GJ/t	Range	Source
02: Wastes from agriculture and food proc.	16.0	12.2-19.5	ETS data
03: Wastes from wood processing	14.0	13.2-14.7	ETS data
Rubber (tires)	26.0		ETS data
Plastic	27.5	22.8-32.1	ETS data
MSW	8.5		FKF 2007 data
Paper	17.0	15.7-18.6	Literature
Hazardous waste	20.0		Estimation
Wastes from waste management facilities	20.0		Estimation
Tire textiles	28.7	27.4-30.0	ETS data

Table 3.7. *NCVs for different waste types in 2009*

As only CO_2 emissions resulting from incineration of carbon in waste of fossil origin should be included in the national CO_2 emission estimate, the fossil fraction of waste had to be determined. To do so, the recommendations of the Background Paper (page 459) published

as a complement to the Revised Guidelines were followed, i.e. a ratio of 0.415 (the average of the range of 0.33 to 0.5) was selected as the fossil proportion of CO_2 assuming a production rate of 1 t CO_2/t waste. On the other hand, the incineration plant also calculated the ratio of the fossil part for 2003, which was 52%, i.e. higher than the default value.
For the more recent years of 2004 to 2009, data of the detailed Waste Management Information System were used which made possible to apply Tier 2 method for calculating CO_2 emissions. For the calculations, country-specific waste amount and composition data were taken from this database and the emission factors were calculated using the default carbon content and fossil carbon fraction data from Table 2.4-2.6 in the 2006 Guidelines. In case of the two biggest incinerators, plant specific data were used. The Waste Incineration Works (FKF) of Budapest determines regularly the composition of incinerated municipal solid waste (MSW), therefore the fossil carbon fraction could easily be calculated with the help of Table 2.4 of the 2006 Guidelines. The fossil carbon fraction of MSW changed between 12.7% and 17.0% showing a growing trend in the last six years. CO_2 emissions were estimated then with the assumption of default oxidation factor.
The biggest co-incinerator plant is Mátra Power Plant. Since this plant reports its verified emissions in the framework of the European emission trading, direct ETS data relating its fuel use and CO_2 emissions were taken over.
For the first time, CH_4 emissions from waste incineration have been added to the inventory. Using the default emission factors (30 kg/TJ) from Table 2.2 of the 2006 Guidelines (Chapter 2: Stationary Combustion), the resulting emissions are not significant at all. The same can be stated about N_2O emissions that were estimated the same way with the default emission factor of 4 kg/TJ.
All in all, waste incineration contributed 250-350 Gg CO_2-eq to GHG emissions in this category recently.

3.2.6.3. Uncertainties and time-series consistency

Practically, the accuracy and uncertainty range of the energy statistics data are determined by the accuracy of the measuring equipment (except for stock changes, which are based on expert estimates and are not comparable with the quantity of fuels from other sources). Taking all this into account, the estimated uncertainty of the energy consumption data is ±2%. This is particularly likely because the quantities of fuels used by power stations were verified using the report of MVM Rt. (Hungarian Power Companies Plc.)
The estimated specific uncertainty for CO_2 is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N_2O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

The time-series are not consistent. Energy consumption of the *manufacturing of solid fuels* is calculated only for the last four years (2006-2009). Until 2005 it is part of the C*hemicals* and *Other Industry* categories. The statistics of gas coke distillation was revised in 2003, but the fuel consumption of this activity cannot be reconstructed from the actual national statistics.

3.2.6.4. Source-specific QA/QC and verification

As mentioned above, energy consumption data were subject of several rounds of verification before use (more details in *Annex 2*).
Energy statistics with those provided to international organizations (prepared also by Energy Centre) are and will be compared after their submission to IEA. This verification pointed out a reallocation problem for 2007 and was corrected in this submission. More details are in the *section 0*.
Verified energy use from EU ETS was compared to statistical data (more details in *Annex A2.3*). It was noticed that data in metric tonnes are similar in the ETS to those in the

statistics, but there are some differences in energy values due to different NCVs. Since the energy consumption in *sectoral approach* should be compared with those of *reference approach*, we kept the NCVs of energy statistics, however emission factors of coals were corrected to achieve consistency in energy balance and verified emissions, too. Measured oxidation factor was also applied in the calculation for the above mentioned reason.
As the main fuel consumption is related to public electricity and heat production, a comparison was also performed with independent dataset collected by the Hungarian Energy Office. For the main power plants the total fuel consumption's difference between the ETS and this dataset was around 1% in 2009.

3.2.6.5. Source-specific recalculations

Following the general guidance given by the ERT during the last in-country review, Hungary switched to the default N_2O emission factor for natural gas.

3.2.6.6. Source-specific planned improvements

The inventory division has now direct access to the emission reports from polluters under the governmental decree 21/2001 (it was indicated in the previous submission). We have began to analyse them, but the accessible dataset must be expanded with other background data (e.g. activity data, information about the calculations'/measurements' method) to create appropriate country/plant specific emission factors. The dataset includes installation from the energy industries and from manufacturing industries, too.
Consumption of coke oven gas is not consistent in the time-series. Activity data for two years is still missing, but the consumptions and emissions (before 2006) will be included in the future submisssions. It has an effect on emissions from *energy industries* and *manufacturing industries and construction* sectors. Coke oven gas was combusted in the coke oven for producing heat for the technology and also in the power and heat plant of the same company for generating electricity and heat for the company and for the town as well. Depending of the main activity of the company and its structural changes these emissions will be allocated to different source categories in the time-series.

3.2.7. Manufacturing Industries and Construction (CRF sector 1.AA.2.)

3.2.7.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2
Emission factors: D, CS, PS
Key source: Level and Trend: Food processing, beverages and tobacco, CO_2; Other, CO_2, Level. Iron and steel

This subsector covers emissions from the combustion of fuels in the industrial sector. Owing to the traditions of the national statistics system, combustion emissions from energy conversion (coke production) was also calculated here between 1985 and 2005. Special attention was paid to avoid double accounting. In the O*ther* subsector (1.AA.2.F) emissions from all the sectors that are not included in the previous listing (A to E) are calculated.
These include:

- Manufacture of non-metallic minerals
  (separate subcategory under the *Other* subsector)
- Mining and Quarrying
- Manufacture of electrical and optical equipment
- Manufacture of transport equipment
- Manufacture of textiles and textile products
- Manufacture of leather and leather products

- Manufacture of wood and wood products
- Manufacturing goods not elsewhere classified
- Construction

Manufacture of iron and steel (IPCC 1.AA.2.A) and non-ferrous metals (1.AA.2.B) are included together under 1.AA.2.A because of statistical reasons.

Emissions in the *Manufacturing Industries and Construction Sector*

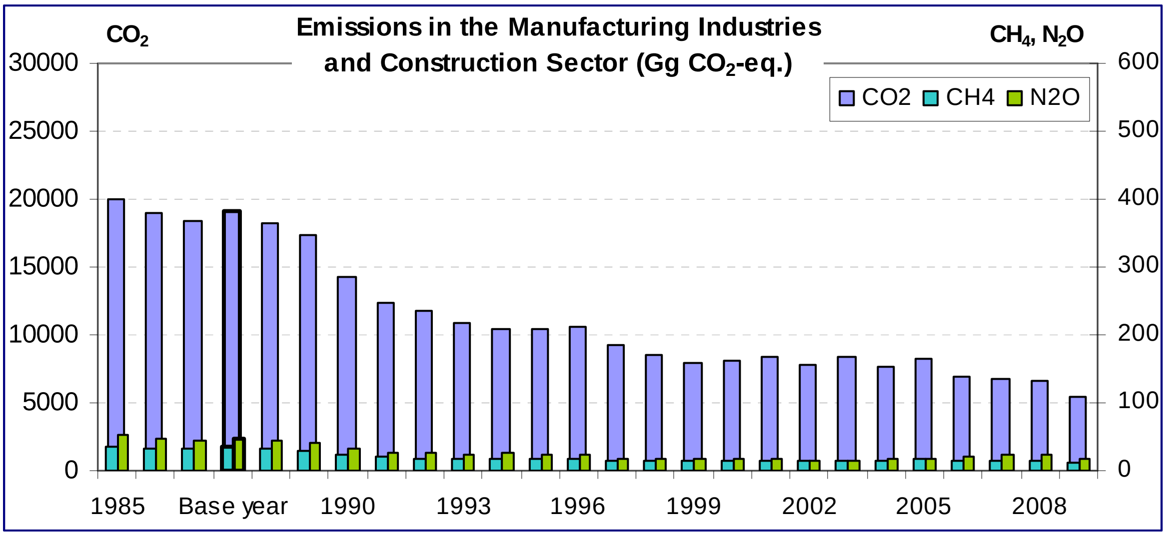


Figure 3.10. *Trends of CO_2, CH_4 and N_2O emissions in the Manufacturing Industries and Construction Sector (1985-2009)*

3.2.7.2. Methodological issues

The energy consumption data were also calculated on the basis of the national energy balance prepared by Energy Centre. The calculation method and the associated problems are the same as those described under the *Energy Industries* (see 3.2.6).

Feedstock and non-energy use of liquid fuels were removed from the *Chemicals* subsector for the entire time-series following the recommendation of the ERT. Now, the CO_2 emission originated from non-combustion processes can be found in the *Industrial Processes Sector*.
Emissions from bitumen used as feedstock for asphalt roofing and road paving with asphalt are moved to 2.A.5 and 2.A.6 sectors, however their CO_2 emissions were never calculated according to the methodology of the IPCC 1996 and 2000 guidance.
The other feedstock and non-energy products are reported under 2.G in two aggregated categories, because the exact place of conversion of feedstock within the chemical industry is not known – presumably it is confidential data because of limited number of manufacturers. The same aggregation was applied for non-energy use of fuels.

Part of the emissions from waste incineration for energy purposes was allocated to this source category. This was possible by using data from the Hungarian Waste Management Information System that contains among others plant-specific data according to business activities in a NACE-code like classification system.
Emissions were calculated the same way as described in chapter 3.2.6.5. First, amount of waste had to be converted to energy units, then the fossil carbon fraction had to be determined based on waste composition data. Special attention was given to the four big cement factories, as they incinerate large amount of waste of fossil origin (plastics, rubber etc.). Their verified ETS data (emissions and fuel use) were analyzed, from which a specific emission factor was derived: 2.2 tonne CO_2/tonne fossil waste. This EF was used for the

years 2004 and 2005 in case of fossil wastes. From 2006 on, ETS data (fuel consumption and emission) of the cement factories were used directly. It could be seen that the other industrial facilities incinerate predominantly waste of biogenic origin, mostly wood waste, therefore their CO_2 emissions did not contribute to the national total. The insignificant CH_4 and N_2O emissions were estimated for all waste (not only fossil but also biogenic) using the default emission factors of 30 kg/TJ and 4 kg/TJ, respectively.

Activity data

Figure 3.11 illustrates the energy consumption of the sector. After 1990, following the economic changes, the quantities of fuels used has been significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data presented in the *Industrial Processes Sector* (*Chapter 4*). In 2005 the higher energy use of the industry is linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products, primarily glass and chemical industry. Growing biomass use has become popular especially for the last three years, like in the *energy industries* sector. Combustion of oil products continues to lose in its weight among fossil fuels. Methane and nitrous oxide emissions from the higher biomass consumption significantly increased the emissions of these gases in this subcategory for the last tree years. In 2009 the global economic crisis continued to reduce the fuel consumption and also the emission of the industrial sector. The fuel mix also changed in 2009, the dominance of natural gas consumption declined and the use of liquid fuels (LPG) deepened.

Feedstocks and non-energy use of liquid fuels were removed from the *Chemicals* subsector, the CO_2 emission originated from non-combustion processes can be found in the *Industrial Processes Sector* (mostly under 2.G).

CO_2 emission in the process of manufacturing bricks and ceramics is calculated using the verified emission reports (EU ETS) in the *Industrial Processes Sector.* In those cases when solid and liquid (petroleum coke) fuels and natural gas were reported together as fuel for the technological heat production, fuel consumption and emission from solid and/or liquid fuels were calculated under the *Industrial Processes Sector*. It was assumed that these fuels serve only as additives increasing the porosity of bricks.

The sudden decrease of the solid fuel CO_2 IEF for iron and steel between 2005 and 2006 is due to the coke oven gas consumption. This type of fuel has very low CO_2 emission factors (see *Table 2.1*). Coke oven gas has been combusted by this company for several years, but the main activity and structure of the company has changed during the past 24 years and the statistical allocation has also changed during the time-series. We would like to revise the allocation of fuels if we got more detailed dataset for the entire time-series.

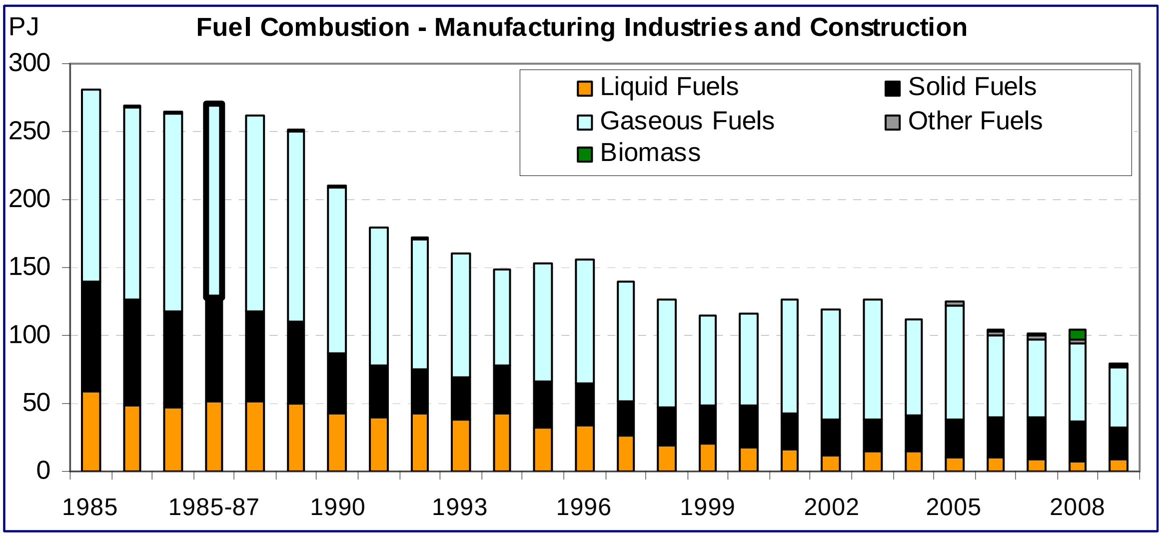


Figure 3.11. *Fuel combustion in the Manufacturing Industries and Construction Sector (1985-2009)*

Emission factors

Mainly default CO_2 factors are used in this sector. There are only two exceptions, namely the coke oven coke and coke oven gas combusted by the iron and steel industry, where measured (by accredited laboratory) carbon content of fuels were available from the EU ETS. According to the measurements the carbon content of coke oven gas and coke oven coke are 11.1 t C/TJ and 29.4 t C/TJ, respectively.

Following the general guidance of the ERT during the in-country review, Hungary switched to default emission factors for methane and nitrous oxide in the entire sector. In former inventories, emission factors were taken from the CORINAIR Guidebook, and from an international literature review prepared by a Hungarian expert (Tajthy, 1994). The following table contains the default values used for the current calculations. The formerly used EFs are in brackets:

Fuel type	CH_4 EF (kg/TJ)	Source of EF	N_2O EF (kg/TJ)	Source of EF
Solid fuels	10.0 (100.0)	1996 Guidelines (Tajthy, 1994)	1.4 (3-5)	1996 Guidelines (Tajthy, 1994)
Natural gas	5.0	default IPCC, 1997	0.1 (3.0)	default (CORINAIR)
Oil	2.0 (2.0-2.2)	default IPCC (Tajthy, 1994)	0,6 (3-10)	default (Tajthy, 1994)
Wood	30.0 (40.0)	default IPCC (Tajthy, 1994)	4.0 (80.0)	default (Tajthy, 1994)

Table 3.8. *Emission factors for CH_4 and N_2O in manufacturing industries and construction*
Values in brackets are the old factors used in previous submissions.

3.2.7.3. Uncertainties and time-series consistency

Practically, the accuracy and uncertainty range of the energy statistics data are determined by the accuracy of the measuring equipment (except for stock changes, which are based on expert estimates and are not comparable with the quantity of fuels from other sources). Taking all this into account, the estimated uncertainty of the energy consumption data is ±2% to 5% in consideration of the fact that uses are less easy traceable due to the high number of users.

The estimated specific uncertainty for CO_2 is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N_2O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

The time-series data is not consistent, because energy consumption of the *manufacturing of solid fuels* is calculated only for the 2006-2009 period in the *Energy Industries* subsector, before that time it is included in the *Chemicals* and *Other Industry* categories.

3.2.7.4. Source-specific QA/QC and verification

Energy consumption data were subject of several rounds of verification before use.
Verified energy use from EU ETS was compared to the statistical data. It was noticed that data in metric tonnes are similar in the ETS to those in the statistics, but there are some differences in energy values due to different NCVs.
Natural gas consumption reported in energy statistics as feedstock of the chemical industry was cross-checked with the *Industrial Processes* sector. Under this process part of the feedstock consumption from the 2.B.1 category was reallocated to the energy sector as fuel gas for process heater last year. See also Ch, 4.4.1.5.

3.2.7.5. Source-specific recalculations

During steel production iron oxide is reduced by carbon. The primary source of this carbon is coking coal. In the previous submissions emissions from coke were reported under the energy sector because of statistical reasons, but also CO_2 emissions were calculated in the industrial processes sector. In the latter case the emission was calculated knowing the carbon content's difference between iron and steel, however the original source of the carbon in iron was the reducing agent. To solve this double counting problem emissions from the 2.C.1.1 category was subtracted from emissions in the 1.AA.2.A category, emissions in the industrial processes sector did not change. *Figure 3.12* shows the results of this changes in the 1.AA.2.C category for the entire time-series.

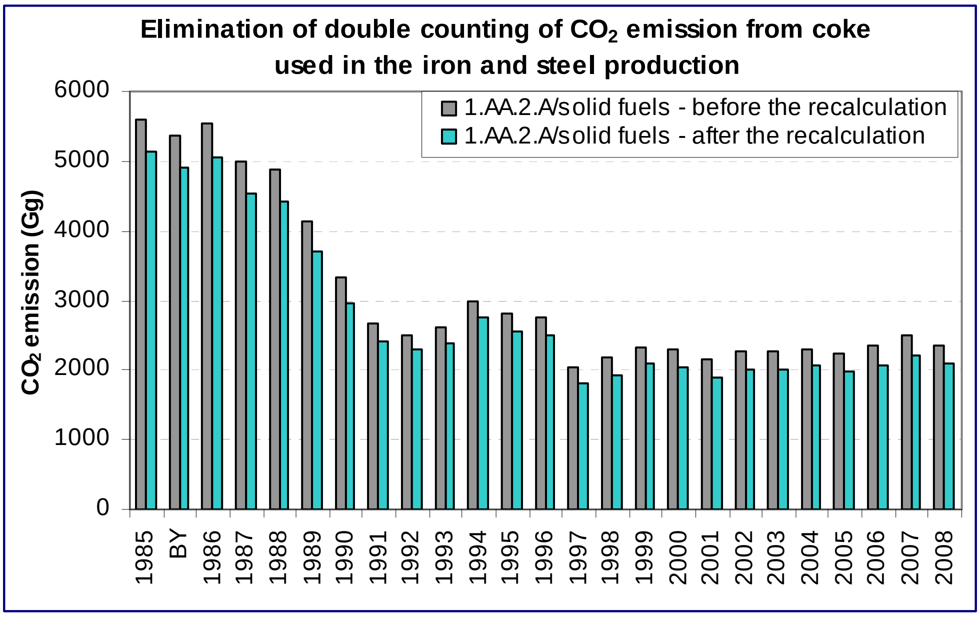


Figure 3.12. *Changes in the CO_2 emissions of 1.AA.2.A category due to the recalculation of coke using*

3.2.7.6. Source-specific planned improvements

It was reported in previous NIRs that the public available statistical disaggregation of manufacturing industries were changed several times. Before 1998 the fuel consumption of each CRF industrial category based on expert estimates knowing changes in industrial production rates and other relevant background information on industrial data. It is planned for 2011-2012 in a framework of a contract with the Energy Centre to recalculate the real consumption of each category according to the database of the Energy Statistics.

3.2.8. Transport (CRF sector 1.AA.3)

3.2.8.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2
Emission factors: D, CS
Key source: Level and Trend: Road transportation, CO_2 and N_2O;
Level: Railways, CO_2

This sector covers all the emissions from fuels used for transportation purposes. International aviation and navigation are excluded.
During the second part of the analyzed period, the composition of the national passenger car fleet underwent considerable changes. The proportion of Eastern European cars characterised by high fuel consumption decreased; currently, almost 90% of the vehicles are more advanced cars. *Figure 3.14* shows the changes in composition of the Hungarian car fleet from 1997.

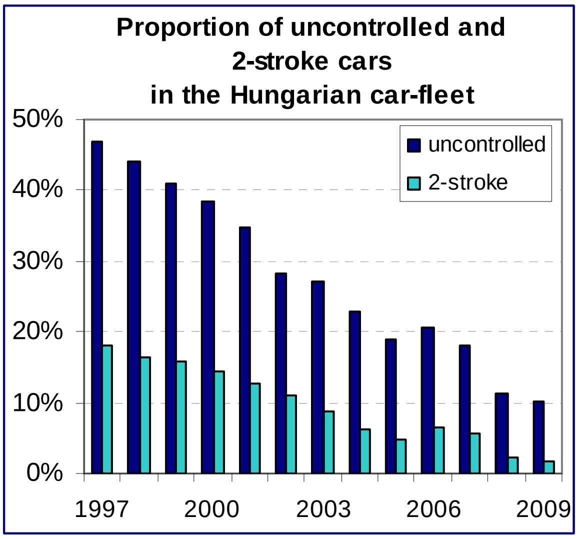


Figure 3.13. *Proportion of the uncontrolled and 2-stroke cars in the Hungarian car fleet (Source: KTI (2006), HCSO (2006), Delta Informatika Zrt (2007-2009))*

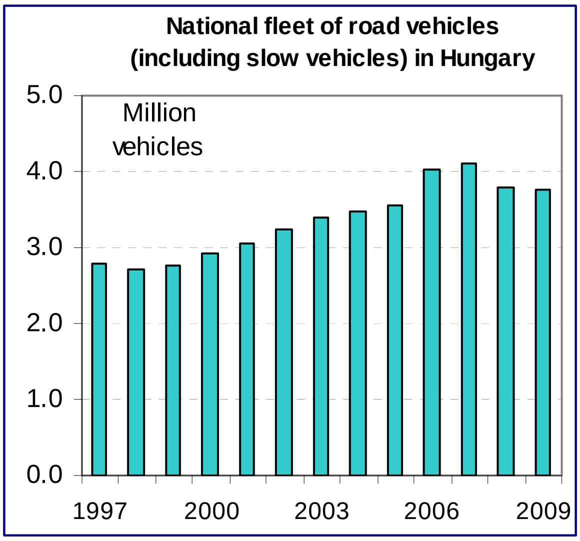


Figure 3.14. *National fleet of road vehicles in Hungary, 1997-2009 (Source: HCSO (1998-1999), Delta Informatika Zrt (2000-2009)*

Electrification of the railways in Hungary decreased the solid fuel consumption by 99.5%. Today there are only few lines – non-scheduled –, which use steam engines.
Emissions were calculated from the national fuel consumption data published in Energy Statistics Yearbook (1985-2010).
National statistics usually does not have separate lines for the quantities of aviation gasoline used for in-country aviation and of the diesel oil used for international (river) navigation (both represent negligible amounts in Hungary). This year the aviation gasoline and the used amount by navigation are included under road transport.
Emissions from combustion related to natural gas transport are included under sector *1.AA.2 (Manufacturing Industries and Construction)* instead of *Other Transport*.
Figures below illustrate fuel consumption of the sector:

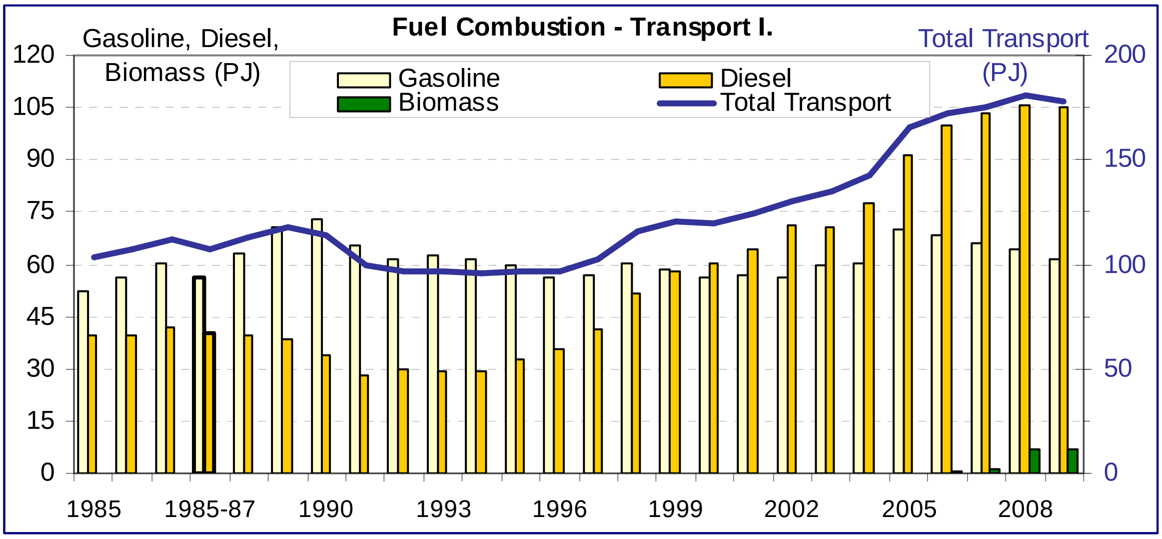


Figure 3.15. *Gasoline, diesel and biomass consumption and total energy use in the Transport Sector (1985-2009)*

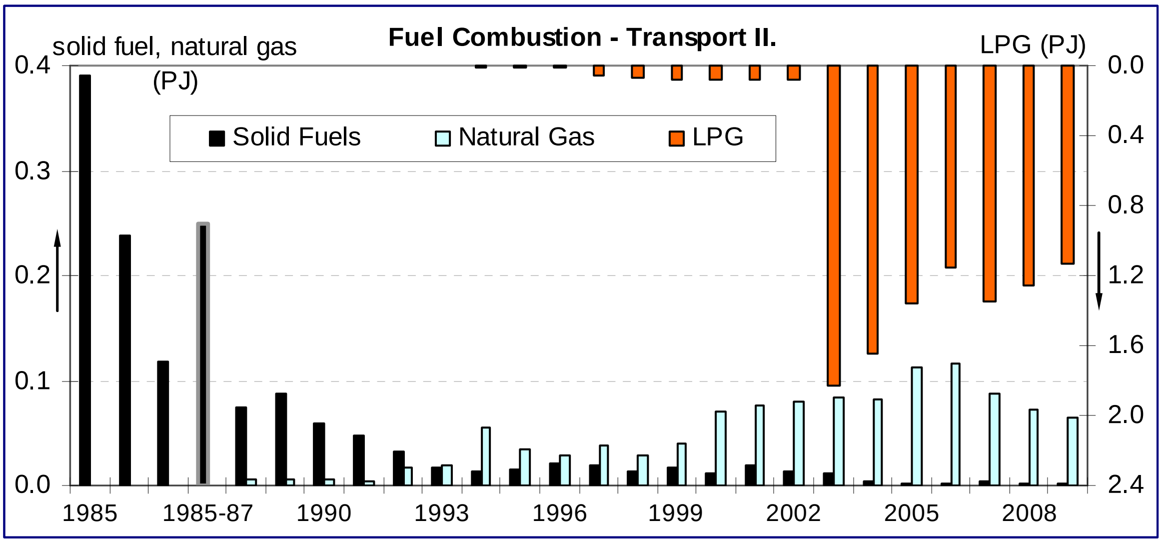


Figure 3.16. *LPG, natural gas and solid fuel combustion in the Transport Sector (1985-2009)*

Figure 3.15. clearly shows that in contrast to the other described sectors, transport consumption shows a rising overall tendency from the mid 90's until 2008. In 2009 the trend of fuel consumption has changed due to the economic crisis. In the second half of 2005 the Hungarian oil and gas company's refinery, MOL Danube Refinery, started to process bioethanol from vegetable raw material with high sugar content, also biodiesel have been used for blending. These bio components appeared in *Figure 3.15* and their use is remarkably growing year by year.

LPG has been used since 1992. It should be noted that due to the current commercial practices, in-container (household, institutional) uses are difficult to separate from traffic uses (i.e., distribution at petrol stations). This may be the reason for the sharp increase in 2003, which does not fully reflect the actual changes but is the result of a change in the approaches used for the preparation of the statistics. Accordingly, liquid fuel uses by the general public (currently including LPG only) show a significant drop – on the basis of the national statistics (see *Chapter 0*).

Emissions in the *Transport Sector*

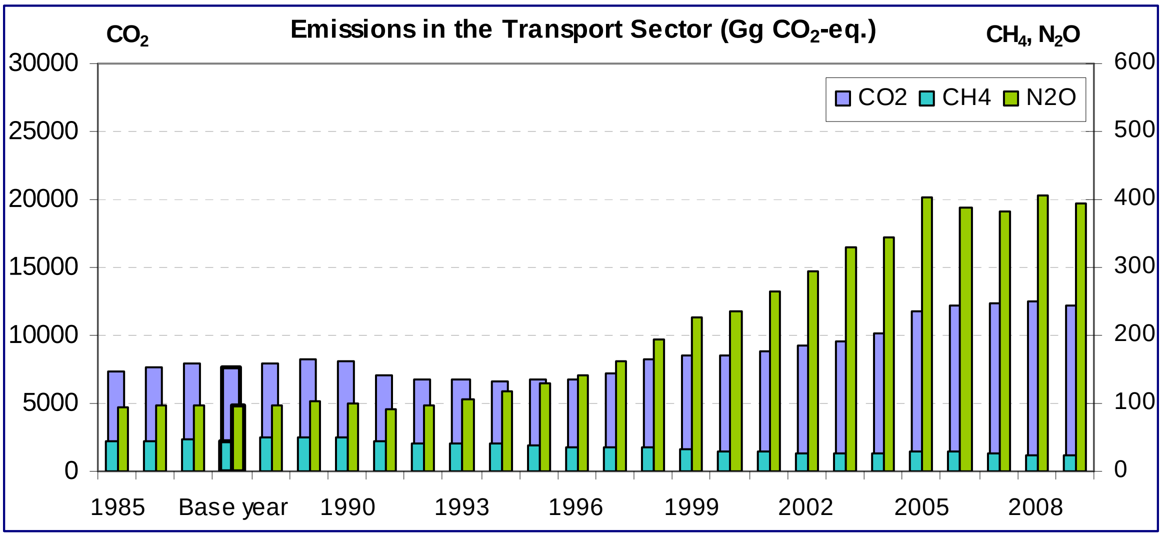


Figure 3.17. *Trends of CO_2, CH_4 and N_2O emissions in the Transport Sector (1985-2009)*

3.2.8.2. Methodological issues

CO_2 emission from transport is calculated by multiplying fuel consumption taken from Energy Statistics Yearbooks (1985-2010) by the default IPCC emission factors.

Calculation of CH_4 and N_2O emissions from road transport was changed a few years ago in conjunction with UNFCCC ERT from Tier 1 to Tier 2 as follows:

Quantification of the stock of each road vehicle type is based on Statistical yearbooks of Hungary and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet (*Figure 3.13*).

For the base years it was assumed that passenger cars with 2-stroke engine have same share in traffic like other gasoline vehicles. This assumption can be applied in the early 1990s, too. For the last few years, data about the use of cars with 2-stroke engine were obtained from KTI (Institute of Transport Sciences) reports and personal communication with experts.

It should be noted that unleaded gasoline was sold only after 1989. Since lead is poison for catalytic converters, therefore these catalytic converters could not work properly. It was assumed that real catalyst vehicle has been used after this time.

Emission factors

Carbon dioxide emissions were calculated on the basis of the guidance on emissions in the Revised 1996 Guidelines (IPCC, 1997). The values of the required factors were taken into account in accordance with instructions related to fuels of the Handbook.

Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
Liquid fuels	Gasoline	18.9	Revised 1996 Guidelines, Table 1-2
	Gas/Diesel Oil	20.2	
	LPG	17.2	
	Residual fuel oil	21.1	

Solid fuels	**Brown Coal**	26.2	Revised 1996 Guidelines, Table 1-2
Gaseous fuels	**Natural Gas**	15.3	Revised 1996 Guidelines, Table 1-2

Table 3.9. *CO_2 emission factors in the Transport Sector*

Non-CO_2 emission factors for road transport in terms of g/MJ and average fuel consumption were obtained from the 2006 IPCC Guidelines and, in case of missing categories, from the 1996 IPCC Guidelines. In case of country specific information the default values were revised as follows:

- the "average passenger cars with 2-stroke engine" have an average fuel consumption of 8.4 litre/ 100 km according to official fuel consumption database (60/1992. (IV. 1.) governmental decree)
- N_2O emission of passenger cars with three-way catalyst, EURO-3 is one third of emission of the cars with early three-way catalysts (2006 IPCC Guidelines, Volume 2, p. 3.22.). Therefore, the default 18 kg/TJ was replaced with 6 kg/TJ. Use of three-way catalyst in new cars is mandatory since 2005 in the European Union, as well in Hungary.

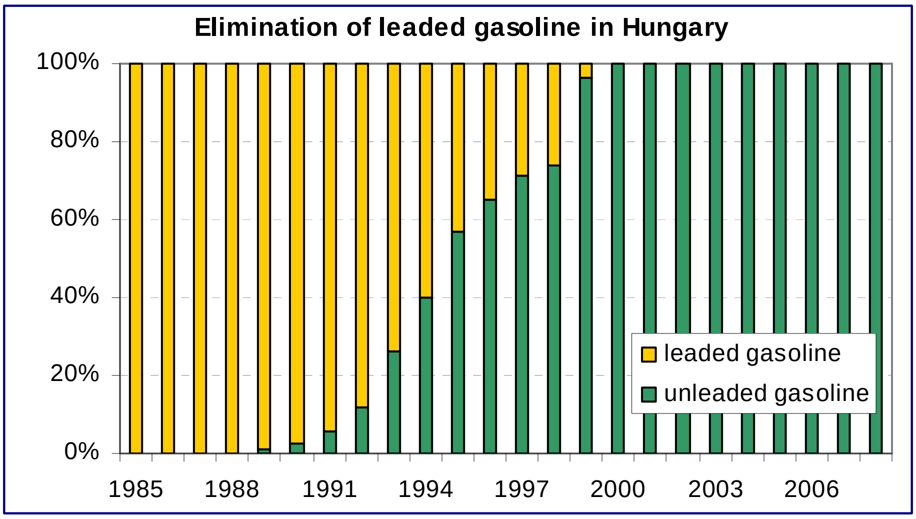


Figure 3.18. *Elimination of leaded gasoline in Hungary*
(Source: Hungarian Petroleum Association (MÁSZ), Annual Reports 1996-2008)

Methane and nitrous oxide emission factors for road transport are summarized in *Table 3.11* and for railways and navigation are shown in the following table. Emissions from in-country aviation, which represent a very low proportion, were taken equal to the emission from consumption of aviation gasoline, and calculated in those years when the related data were available in the energy balance. Where aviation gasoline was not indicated in a separate line, consumption and emissions are calculated together with road traffic gasoline.

Category	Fuel type	Emission factor (kg/TJ)	
		CH_4	N_2O
Railways	Liquid fuels	**5.0**	6.0
	Solid fuels –Brown coal	80.0	12.0
Navigation	Gas/Diesel Oil	5.0	5.0
Civil aviation	Aviation Gasoline	0.5	2.0

Table 3.10. *CH_4 and N_2O emission factors in the Transport Sector (excluding road transport)*
Values in bold are new factors (from the 1996 Guidelines (IPCC, 1997)) in this submission according to the recommendation of the ERT 2010 review.

3.2.8.3. Uncertainties and time-series consistency

We assume that the uncertainty of the transport-related fuel consumption data is higher than in case of immobile equipment because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is ±5%. The estimated uncertainty of the emission factors for CO_2 is ±5-15% for CH_4 is 50%, whereas that of N_2O is 100%. It should be noted, that in the 2006 IPCC Guidelines the uncertainty for default methane and nitrous oxide factors is much higher (200-300%).

3.2.8.4. Source-specific QA/QC and verification

None.

Table 3.11. *CH_4 and N_2O emission factors in the Road Transport Sector*

Fuel type	Vehicle type	Emission control technology	Emission factor (kg/TJ)		Average fuel consump-tion (l/100km)	Source of EFs and average fuel consumption
			CH_4	N_2O		
Gasoline	Passenger car	Uncontrolled	33.0	3.2	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		Non-oxidation catalyst	25.0	8.0	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		2-stroke engine	20.0	1.0	8.4	EF: Revised 1996 Guidelines, Table 1-36; Fuel: country specific information
		Three-way catalyst	7.0	18.0	8.5	Revised 1996 Guidelines, Table 1-36
		Three-way catalyst EURO-3	4.0	6.0	8.5	Expert judgement using IPCC, 2006 Guidelines, V2 Table 3.2.3
		Three-way catalyst EURO-4	1.5	6.0	8.5	Expert judgement using IPCC, 2006 Guidelines, V2 Table 3.2.3
	Motorcycles		100.0	1.5	4.0	Revised 1996 Guidelines, Table 1-42
	Light duty vehicle	Uncontrolled	20.0	1.0	13.6	Revised 1996 Guidelines, Table 1-40
		Catalyst (1997 or later)*	3.8	5.7	11.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: expert judgement
	Heavy duty vehicle	Uncontrolled	20.0	1.0	22.5	Revised 1996 Guidelines, Table 1-41
		Catalyst (1997 or later)*	3.8	5.7	22.5	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: Revised 1996 Guidelines, Table 1-41
	Bus		20.0	1.0	22.5	Expert judgement, assuming same performace like heavy duty vehicle
LPG	Passenger car		62.0	0.2	11.2	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-45
Natural Gas	Passenger car		92.0	3.0	9.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement
Diesel	Passenger car		2.0	4.0	7.3	Revised 1996 Guidelines, Table 1-37
	Light-duty vehicle		3.9	3.9	10.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-38
	Heavy-duty vehicle		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel Revised 1996 Guidelines, Table 1-39
	Bus		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement, assuming same performace like heavy duty v.

** It was assumed, that the technology change was slower in Hungary than in Western Europe or in the USA. IPCC, 2006 suggests the low Efs after 1995*

3.2.8.5 Source-specific recalculations

3.2.8.6 Source-specific planned improvements

The time series for the N_2O and CH_4 emissions for gasoline and diesel used in road transportation were recalculated in the last submission for the years 1988-2003. Since the appropriately detailed datasets are still missing, it was decided to fill the gap with the help of existing datasets and background information (e.g. consumption of gasoline types). The generated emissions for the missing years fit in well with the trend of implied emission factor, however it is expected that these results will be refined in the future..

3.2.9. Other Sector (CRF sector 1.AA.4)

3.2.9.1 Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1
Emission factors: D, CS
Key source: Level and Trend: Commercial/institutional, CO_2; Residential, CO_2; Agriculture/Forestry/Fisheries, CO_2, Trend: Residential CH_4

This sector covers combustion in public institutions, by the population and in the *Agriculture/Forestry/Fisheries Sector*.

Emissions in the *Other Sector*

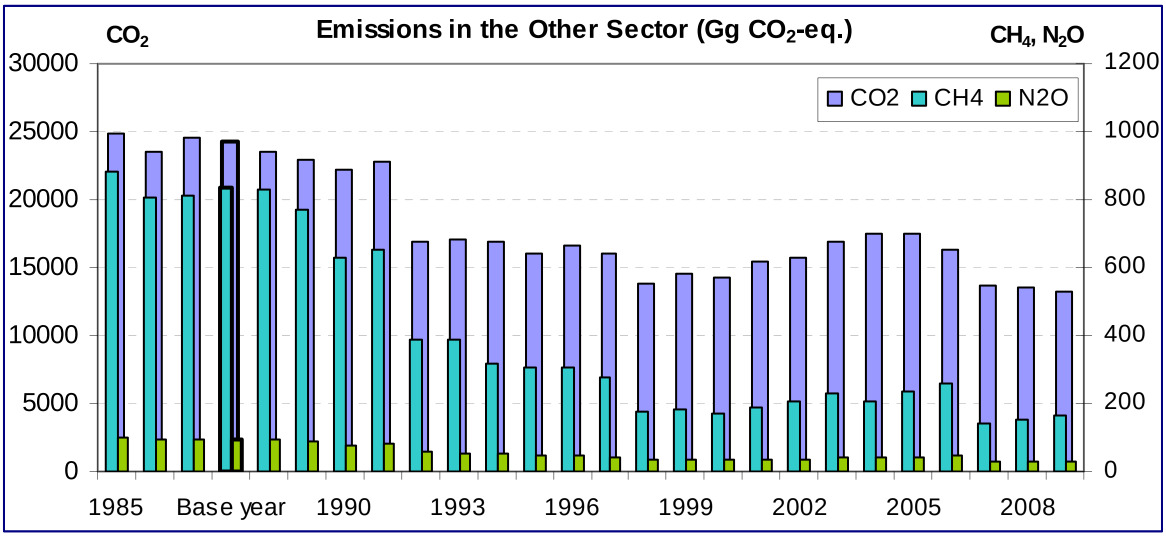


Figure 3.19. *Trends of CO_2, CH_4 and N_2O emissions in the Other Sector (1985-2009)*

HDD and energy demand of the *Residential Sector*

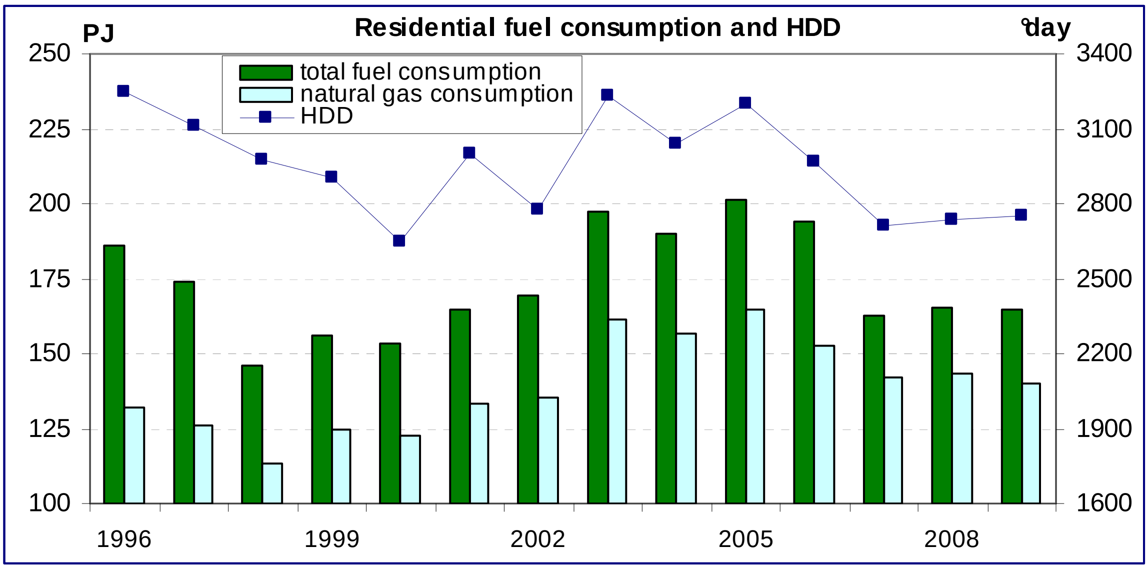


Figure 3.20. *Comparison of residential fuel consumption and HDD between 1996 and 2009*

Heating degree day (HDD) is a quantitative index which reflect demand for energy to heat houses and businesses. This index is derived from daily temperature observations. The inside temperature is 18℃ and base temperature (the outside temperature above which a building needs no heating) is 15℃ in our calculation (following the standard European methodology). *Figure 3.20* illustrates the relationship between residential fuel consumption and HDD. Line of HDD and fuel consumption bars are running parallel, especially in the last 6-7 years.

3.2.9.2 Methodological issues

Activity data

Activity data was obtained from energy statistics as described in the introduction section of the chapter (*Section 3.1*). *Figure 3.21* illustrates the fuel consumption of the sector by types.

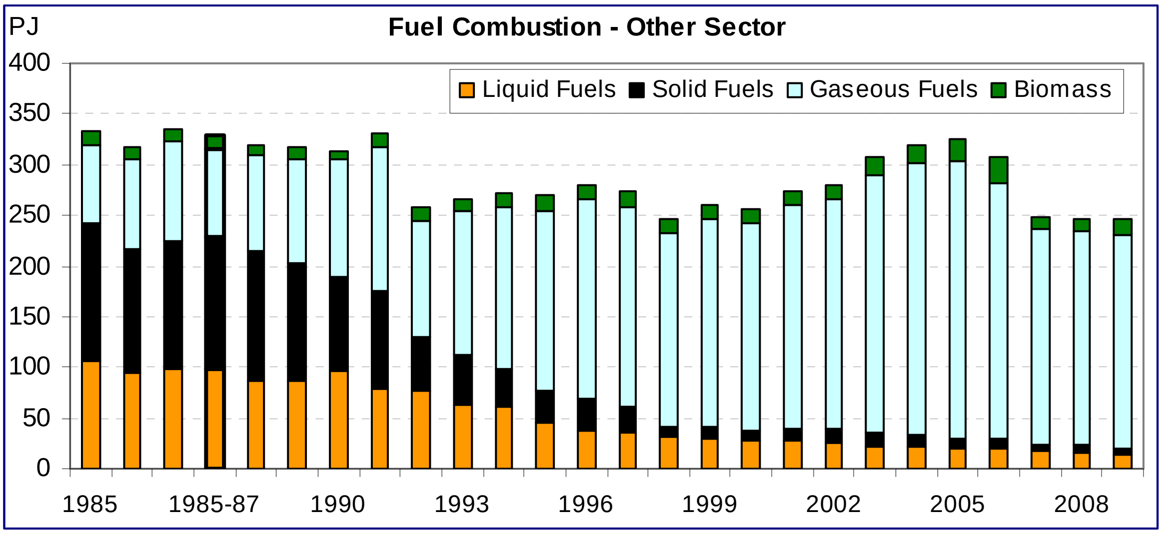


Figure 3.21. *Share of different combusted fuel types in the Other Sector (1985-2009)*

Since 59-74% of the fuel consumption is related to the *Residential Sector*, the fuel structure is influenced principally by the changes in this sector. In contrast with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. During the period 1985-2008 natural gas transmission pipelines length has doubled (see *Table 3.19*), and the number of households supplied with natural gas has been increasing continuously, which is illustrated by the length of the distribution pipelines. Population □witched from coal to natural gas combustion. Household heating oil was completely replaced by LPG during the last years of the analyzed period, as shown in *Table 3.12*, but consumption of the total liquid fuels has been decreased significantly caused by the spread of natural gas supply. This sector used nearly the same amount of energy in 2008 and 2009, but its emission decreased by 2% due to the higher share of biomass.

Sector	Fuel consump-tion (TJ)	2000	2003	2004	2005	2006	2007	2008	2009
Commercial/ Institutional	Oil	1,127	366	744	289	41	325*	36*	0
	LPG	2,131	1,739	1,643	1,609	1,595	1,399	896	861
Residential	Oil	54	0	0	0	0	0	0	0
	LPG	12,091	9,353	8,836	6,688	6,890	3,943	3,673	3,351

Table 3.12. *Oil and LPG consumption in the Commercial/Institutional and Residential Sectors in selected years after 2000*

** without transport, storage and communication*

As the dominant fuel is natural gas in the O*ther Sector*, the following basic statistical data will help to get acquainted with the Hungarian situation (source: HCSO, 2010).
Residential consumption represented 42% of total natural gas consumption (transported by pipelines) in 2009. 91.2% of the settlements were supplied with this facility in 2009. Some 84% of households use natural gas for heating purpose as well. Sold natural gas for residential consumer decreased by 5.5% in 2009 compared to 2008, because consumer price index of natural gas increased significantly. After 1990 individual residential heating became widespread, but still more than 15% of dwellings (of which 36% exists in the capital city) are supplied with district heating based also mainly on natural gas – this emission was calculated under the *Energy industries* subsector.

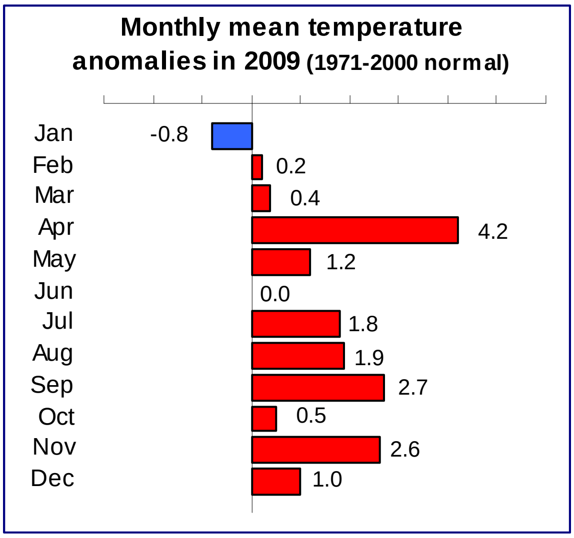


Figure 3.22. Monthly mean temperature anomalies in 2009 (1971-2000 climatical average)

Annual mean temperature was 1.3℃ higher in 2009 compared to 1971-2000 climatical average and -0.2℃ lower than in 2008, also the heating period was cooler than in 2008; but the total fuel consumption of the *Other Sectors* decreased only by 0.5% compared to 2008. Budapest Gas Works Plc. have established that in 2007 and 2008 the residential gas consumption dropped by 7-8% (after weather correction) in the capital city, which is the joint impact of the following factors: more expensive tariff, modern heating systems and insulations. Further rising tariffs and the economic crisis is the main reason of more biomass use in this sector in 2009.

The consumption rates of the subsectors are shown in *Figure 3.23*.

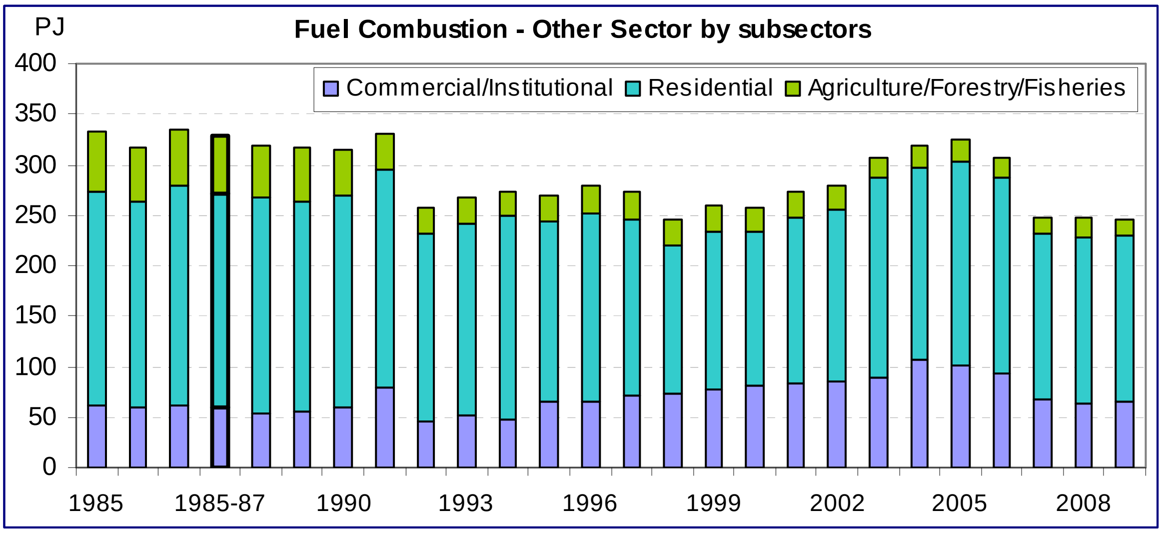


Figure 3.23. *Fuel combustion in the subsector of the Other Sector (1985-2009)*

Emission factors

Default emission factors for CO_2 are used for liquid and gaseous fuels and for most of the solid fuels. The only exception is the residential lignite emission factor, which is the same as described in *Section 0 Table 3.5*, because the power plant, which reported the measured

carbon content of lignite, sold directly this amount to the consumers.
Since the entire quantity of liquid fuels used in residential combustion is LPG and the majority of institutional uses is also based on LPG, the IEF factor for CO_2 is very low.
Due to the relatively high briquette consumption in the agriculture, the used average factor for solid fuels is lower than in the other sectors.

Specific emission factors for CH_4 are shown in *Table 3.13*. As in this submission default values were chosen to be used consistently, some Efs were changed. (Changed values are in bold, formerly used Efs are in brackets.)

Emission Factors for CH_4 (kg/TJ)	Solid	Natural Gas	Liquid fuels	Wood
Commercial/Institutional	**10** (100)	5	10	300
Residential	300	5	10	**300** (470)
Agriculture	300	5	10	300.0

Table 3.13. *Specific emission factors for CH_4 in the Other Sector*

Country specific N_2O emission factors were replaced by IPCC 2006 default values in gaseous fuels in the *Residential Sector* and liquid and gaseous fuels in the *Agriculture/Forestry/Fisheries Sector* and solid fuels in general in the 2008 submission according to the suggestion of UNFCCC expert review team. Specific emission factors for N_2O are shown in *Table 3.14*. Changed values are in bold.

Emission Factors for N_2O (kg/TJ)	Solid	Natural Gas	Diesel	LPG	Residual Fuel Oil	Wood
Commercial/Institutional	1.5	**0.1** (2.5)	**0.6** (10.0)	**0.6** (2.0)	**0.6** (2.0)	**4.0** (4.3)
Residential	1.5	0.1	**0.6** (10.0)	**0.6** (2.0)	**0.6** (2.0)	**4.0** (4.3)
Agriculture	1.5	0.1	0.6	**0.6** (0.1)	0.6	4.0

Table 3.14. *Specific emission factors for N_2O in the Other Sector*

3.2.9.3 Uncertainties and time-series consistency

We assume that the uncertainty of the fuel consumption data of the *Other Sector* is higher than in case of industrial processes because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is less than ±10%. The estimated uncertainty of the emission factors for CH_4 is moderate (±30% to 35%), whereas that of N_2O may be very high, i.e., 50% to 100%, as mentioned above.

3.2.9.4. Source-specific QA/QC and verification

None.

3.2.9.5 Source-specific recalculations

Following the general guidance by the ERT, default emission factors were used consistently. See Table 3.13 and 3.14 for details.

3.2.9.6 Source-specific planned improvements

We stated in previous submission, that it is planned to investigate the relation of fugitive emission from natural gas pipelines and emission from *residential* and *commercial/institutional* natural gas consumption. This revision is in progress.

3.3. Fugitive emissions from solid fuels and oil and natural gas (CRF sector 1.B)

3.3.1. Solid fuels (CRF sector 1.B.1)

3.3.1.1. Source category description

Emitted gas: CH_4
Methods: D, T2
Emission factors: CS
Key source: Trend: Solid Fuels, CH_4

This category includes fugitive CH_4 emission released during coal mining and handling. Emissions from fuels used during these activities are calculated under sector 1.AA.2 (*Manufacturing Industries and Constructions*).
In Hungary, both underground and surface coal mines are present. Although underground mining was the predominant form in the 1960's and 1970's, it represents only 14% today. Drastic reduction in coal production was observed between 1987 and 1988, as well as between 1989 and 1990 (see *Table 3.15*). Underground mining continues to decrease in both relative and absolute terms, therefore distribution of mined coal types underwent significant changes (*Figure 3.25*).

Fugitive emissions from solid fuels

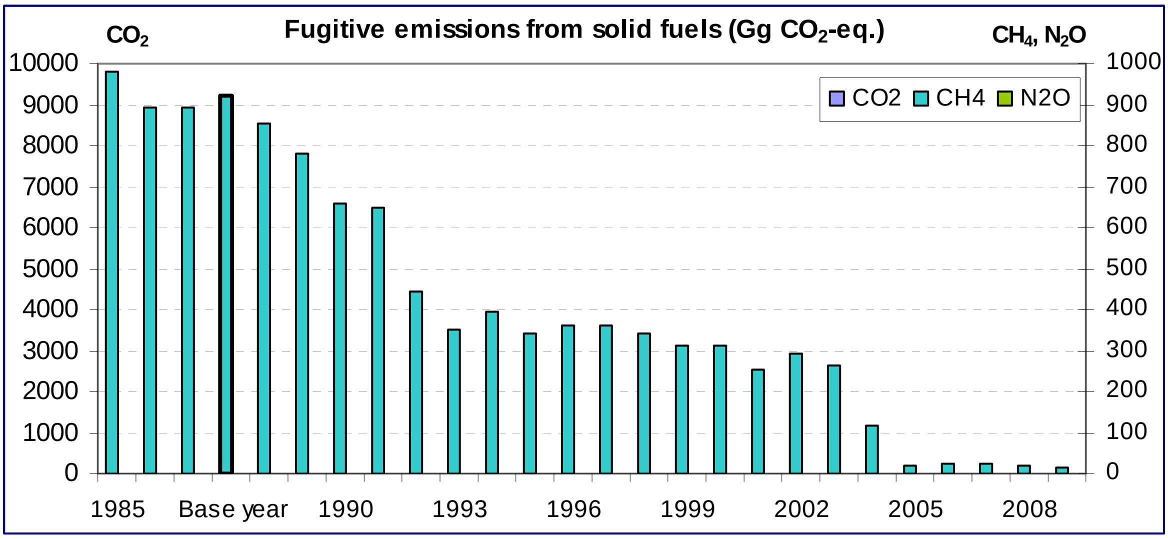


Figure 3.24. *Trends of CO_2, CH_4 and N_2O emissions from solid fuels (1985-2009)*

3.3.1.2. Methodological issues

Emission calculations are based on detailed activity data. The actual quantities released into the atmosphere are obtained by multiplying the data by the specific emission factors.

Year	1985	1986	1987	1990	1995	2000	2005	2006	2007	2008	2009
Coal production (10^6 t)	24.04	23.13	22.84	17.66	14.59	14.03	9.57	9.95	9.82	9.40	8.99

Table 3.15. *Coal production of selected years in Hungary*

Activity data

Production data were taken from the HCSO and Energy Statistics Yearbooks. These statistical yearbooks provide the production of surface and underground mines together for each coal type.

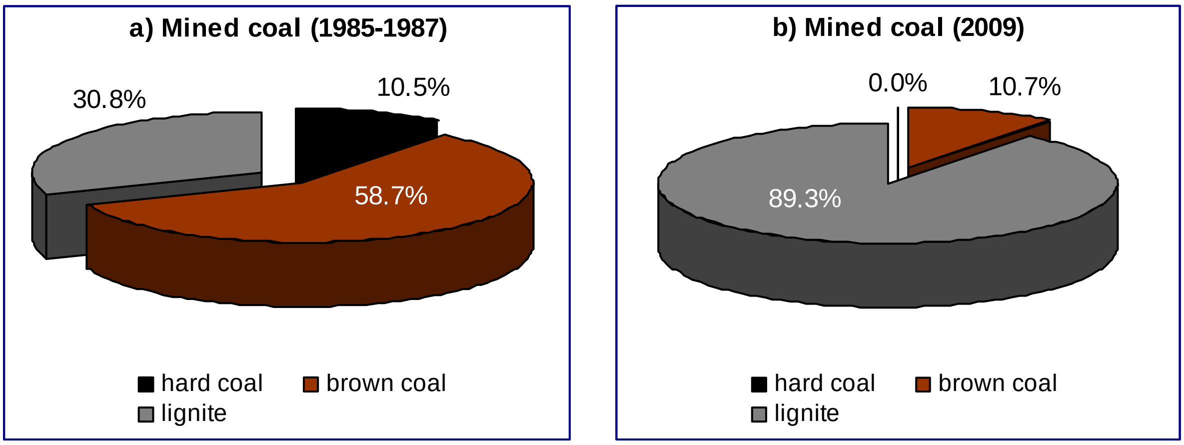


Figure 3.25. *Distribution of mined coal in the base year (a) and 2009 (b)*

Hungarian mines are not drained. There are no mine-burning or burning coal waste piles. From the older coal waste piles the combustible part has been extracted for decades. Abandoned mines are gobbed and are flooded with water – based on the information of the Mining Property Utilization Company in the Public Interest –, therefore methane emission can be negligible.

Emission factors

Emission factors were taken into consideration according to the information from Mining Bureau of Hungary and measurement data from mines. Emissions were calculated for the following categories: hard coal, brown coal and lignite (*Table 3.4*).
Both mining types occurred in hard and brown coal mining, but there is only limited information about the production, therefore the total amount of hard coal and brown coal was taken into account as underground mining.

Table 3.16 shows the measured methane content of coal for the active mines in Hungary in the last few years. Mine of Lencsehegy closed in 2004, previously it had been producing significant amount of coal having 0.0 m^3/t methane. Since 2006 the only one operating mine has been Márkushegy with 0.93 m^3/t in-situ methane content. Lignite is mined only in surface mines; where – based on measurement data – methane is not emitted during mining activity, since the Hungarian lignite is relatively young in the coalification (NCV is under 10 MJ/kg).

Coal type	Mine	In-situ CH_4 content (m3/t)
Hard coal	Pécsbánya – Karolina	18.26
	Vasas – Észak	20.75
Brown coal	Balinka	1.29
	Lencsehegy	0.00
	Mány I/a	0.98
	Márkushegy	0.93
Lignite	Bükkábrány	0.00
	Visonta	0.00

Table 3.16. *In-situ CH_4 content in Hungarian mines*
(Source: REKK, 2004 (original data: Hungarian Geological Survey, disclosure of mines))

Emission factors for coal mining and post-mining are summarized in the following table (*Table 3.17*). For mining activities emission factors were derived from measurement data, in case of post-mining according to the IPCC 2000 Guidance, emission factor was calculated as 10% of the value of mining factor. The new emission factors are lower than the default ones.

Coal mining		Emission factor ($kg\ CH_4/t$)	
		Default	Hungarian
Underground mining	Hard coal	6.700-16.750	13.065
	Brown coal		0.670 0.623*
Post-mining	Hard coal	0.603-2.680	1.340
	Brown coal		0.067 0.0623*
Surface mining	Lignite	0.201-1.340	0.000
Post-mining		0.000-0.134	0.000

Table 3.17. *Comparison of IPCC default and country specific emission factors for coal mining*
** after 2005 only one mine has been operating and its in-situ methane content is known*

3.3.1.3. Uncertainties and time-series consistency

The uncertainty of this source category is originated from the categorization of activity data and use of measured emission factors. The combined uncertainty of the sector is approximately 10%.

3.3.1.4. Source-specific QA/QC and verification

None.

3.3.1.5. Source-specific recalculations

3.3.1.6. Source-specific planned improvements

It is planned to separate the amount of mined brown and hard coal to underground and surface types. This new categorization will reduce the methane emission and also the uncertainty of the sector in some extent.

3.3.2. Oil and natural gas (CRF sector 1.B.2)

3.3.2.1. Source category description

Emitted gas: CO_2, CH_4, N_2O
Methods: D, CS
Emission factors: D, CS, OTH
Key source: Level and Trend: Oil and Natural Gas, CH_4

In the past, oil production and processing was an important sector in Hungary, but production's importance is decreasing as the reserves are running out. Gas mining shows similar tendencies, although the reduction is less intensive. At the same time, natural gas uses show a significant increase as a result of the sharply growing import.

Fugitive emissions from oil and natural gas activities

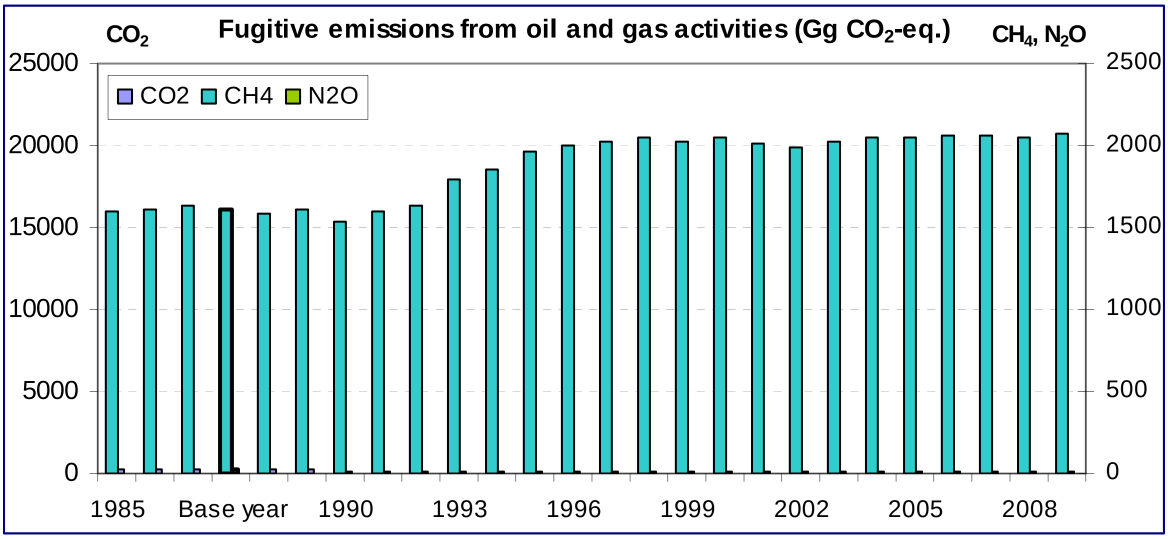


Figure 3.26. *Trends of CO_2, CH_4 and N_2O emissions from oil and natural gas activities (1985-2009)*

3.3.2.2. Methodological issues

Activity and consumption data related to extraction and primary handling were taken from Energy Statistics Yearbook. In addition, data from the HCSO and from production companies were used.

In the past, emissions were calculated using the specific emission factors provided for *Eastern European technologies* in the Revised 1996 Guidelines. In response to the comments of the ERT and also due to the ambiguous relationship between activities and specific emission factors, we contacted the production companies and the emission calculations were adjusted in cooperation with them, on the basis of the new information obtained. Such fundamental changes were required because the technologies used in Hungary are entirely based on "Western" equipment; therefore, the use of the specific emission factors for Eastern Europe, which are high and associated with great uncertainty, is not justifiable. Since we do not have own measurements, it was decided – on the basis of the data available from the production companies – that the Canadian calculation presented in the Background Papers published by IPCC (2002) would be used. Hungarian data for the activities indicated in this calculation were determined and multiplied by the provided specific emission factors.

The included technologies and the applied specific emission factors are as follows:

Oil and Gas Activities (unit)	CH_4 emission factors (Gg/unit)
Wells – Drilling (number)	$4.3 \cdot 10^{-7}$
Wells – Testing (number)	$2.7 \cdot 10^{-4}$
Wells – Servicing, (number)	$6.4 \cdot 10^{-5}$
Gas Production ($10^6 m^3$)	$3.1 \cdot 10^{-3}$
Gas Processing – Sweet Gas Plants ($10^6 m^3$)	$7.1 \cdot 10^{-4}$
Gas Processing – Sour Gas Plants ($10^6 m^3$)	$2.4 \cdot 10^{-4}$
Gas Processing – Deep-cut Extraction Plants ($10^6 m^3$)	$7.2 \cdot 10^{-5}$
Gas Transmission (km)	$3.4 \cdot 10^{-3}$
Gas Storage ($10^6 m^3$)	$8.4 \cdot 10^{-4}$
Gas Distribution (km)	$5.2 \cdot 10^{-4}$
NGL Transport – Condensates and Pentanes Plus ($10^6 m^3$)	$1.1 \cdot 10^{-4}$
Oil Production – Conventional ($10^6 m^3$)	$1.8 \cdot 10^{-3}$
Oil Transport – Pipelines ($10^6 m^3$)	$5.4 \cdot 10^{-6}$
Oil Transport – Tanker Trucks and Rail Cars ($10^6 m^3$)	$2.5 \cdot 10^{-5}$

Table 3.18. *Source-specific emission factors in oil and gas activities (Source: IPCC – Background Papers, 2002)*

In addition, trial calculations were made using the specific emission factors for "Western" technologies from the Revised 1996 Guidelines. The results were in the same order of magnitude as before. Energy Statistic Yearbook contains a special category, the network loss, which is a statistical concept. The real fugitive emission is about one third of the network loss in natural gas distribution. The results of the above mentioned methodology and emission factor are in good agreement with the statistical value.
Gas transport represents the highest proportion in the emissions. In Hungary, gas supply, as well as the total length of pipelines, has been growing significantly over the past 20 years. Annual data for pipeline lengths are indicated in *Table 3.19.*
Flaring was estimated – due to lack of information about emission – on the basis of detailed production data obtained from oil and gas companies and using default emission factors of the 2006 Guidelines (IPCC, 2006).
CH_4 and N_2O emissions from flaring (oil and gas) are included for the first time, in this submission.

Pipeline length (km)										
Year	1985	1986	1987	1990	1995	2000	2005	2007	2008	2009
Transmission	3,544	3,681	3,889	4,046	4,684	5,767	5,193	5,207	5,300	5,564
Distribution	10,262	12,474	14,200	22,559	53,436	72,540	80,519	81,555	82,128	82,565

Table 3.19. *Annual data for natural gas pipeline lengths in selected years*

3.3.2.3. Uncertainties and time-series consistency

The uncertainty of the majority of the activity data from recent years is favourable. These include main production data and pipeline lengths. The uncertainty of other values and specific emission factors is moderate; however, in the lack of other information, this cannot be quantified, only estimated. Naturally, the uncertainty of older data is higher due to the incomplete availability of the required information.
Flaring from oil refining is reported under the 1.B.2.C.2.1 category with flaring of oil production but only for the 2005-2009 period. Source of the emission data was the EU ETS

reports.

3.3.2.4. Source-specific QA/QC and verification

1.B.2.C.2.1 Oil flaring CO_2 emission was recalculated for 2006-2008 because formerly a wrong equation had been used.

3.3.2.5. Source-specific recalculations

We received corrected activity data for the following categories from the Hungarian Oil and Gas Company Plc. (MOL):

CRF code	category name	modified GHG emission	recalculated year
1.B.2.C.2.2	Gas flaring	CO_2, CH_4, N_2O	2008
1.B.2.A.3	Oil transport	CH_4	2008
1.B.2.B.2	Gas processing	CH_4	2008
1.B.2.B.2	Gas transmission	CH_4	2008

Table 3.20. *Recalculated categories of fugitive emissions from oil and natural gas*

3.3.2.6. Source-specific planned improvements

Fugitive emissions from distribution of oil products are reported as not estimated (NE). They will be included as soon as appropriate emission factor will be available for this category.

3.3.3. Other fugitive sources related to oil and natural gas activities (CRF sector 1.B.2.D)

3.3.3.1. Source category description

Underground storage and CH_4 emission from thermal water

Emitted gas: CH_4
Methods: CS
Emission factors: OTH, CS
Key source: Level and Trend: Oil and Natural Gas, CH_4

This category contains the emissions from underground storage of natural gas, thermal and other deep water drills. In Hungary, and especially in the Great Plain, subsurface waters and deep wells drilled for various purposes contain varying quantities of methane. Upon the abstraction of such waters (as drinking and/or as thermal water), methane is also abstracted and released into the atmosphere.

3.3.3.2. Methodological issues

Underground storage

The methodology and emission factor were obtained from the previously mentioned IPCC Background Papers (2002), because the technology used in Hungary is entirely based on “Western” equipment. Activity data of this category is the annual mean of stored natural gas in exhausted reservoirs, it can be found in the online publication of the Hungarian Energy Agency.

CH_4 emission from thermal water

According to a previous expert estimate, the annual quantity of methane released from wells is approx. 20 Gg. We believe that this item should also be included in the methane emissions for the sake of completeness. However, it does not have an appropriate “slot” in the inventory. Thus, such emissions were included among fugitive emissions from oil and natural gas *(1.B.2.D Other)* in the following way: the emissions are indicated in the CH_4 column but the box for activity data was left empty because emissions are not related to fuel consumption or fuel production.

3.3.3.3. Uncertainties and time-series consistency

Since the emission of thermal water and other deep water drills is based on expert estimate, the uncertainty can be very high. According to the IPCC Good Practice Guidance (2000) the uncertainty of underground storage can be an order of magnitude.

3.3.3.4. Source-specific QA/QC and verification

None.

3.3.3.5. Source-specific recalculations

None.

3.3.3.6. Source-specific planned improvements

It is planned that emissions from thermal water and other deep water drills will be analyzed in more details. So far, the capacities have been insufficient for the collection and evaluation (including retrospective collection and evaluation) of potentially available data from some ten thousands of wells. Last year the Hungarian Central Statistical Office started to collect data from baths using thermal water, after the official publication the results will be taken into account in the CH_4 calculation.

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4. INDUSTRIAL PROCESSES (CRF sector 2.)

4.1. Overview of sector

Industrial Processes sector includes emissions generated by non-firing processes related to industrial production. Emissions from the industrial processes are the third largest following the energy and agriculture sectors (see *Figure 2.7.* in Chapter 2).
Emissions from this category comprise the following sub categories: Mineral Products (CRF 2.A.), Chemical Industry (CRF 2.B.), Metal Production (CRF 2.C.), Other Production (CRF 2.D.), Consumption of Halocarbons and SF_6 (CRF 2.F.) and Other (CRF 2.G).
Under Mineral Products Hungary reports the emissions from cement production (CO_2, SO_2), lime production (CO_2), limestone and dolomite use (CO_2), asphalt production (CO, NMVOC), glass (CO_2, NMVOC), bricks and ceramics production (CO_2). Under Chemical Industry emissions from ammonia (CO_2, CO, NMVOC, SO_2), nitric acid (N_2O, NO_X, CO_2), and other chemical production (CH_4, NMVOC, SO_2), for example carbon black and ethylene are reported. Under Metal Industry emissions from pig iron (CO_2, CH_4), steel (CO_2, CH_4) ferroalloys (CO_2), aluminium (CO_2, CF_4, C_2F_6, NO_X, CO, SO_2) are taken into account. Consumption of halocarbons and SF_6 means emissions from different source, for example: refrigeration, air conditioning equipment, foam blowing, aerosols, electrical equipment. The 2.G sector contains emissions from non-energy use of fuels and feedstock (CO_2).
The base year is the average of 1985–1987 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6.

Figure 4.1 shows the main sources of greenhouse gas emissions:

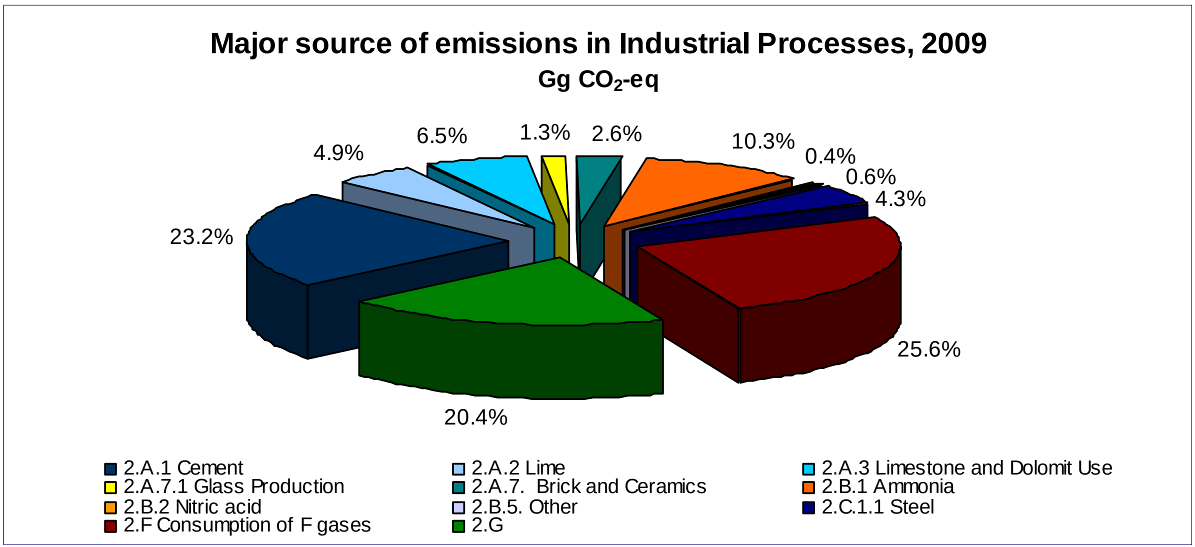

Figure 4.1. *The major processes in Industrial sector, 2009 (Gg, CO_2-eq)*

4.2. Emission Trends

Total emissions estimated from industrial processes were 4,195.66 Gg CO_2-eq in 2009, or 6.3% of the total national emissions compared to 9.0% in the base year. Total sectoral emissions decreased by 61.9% between the base year and 2009, and by 17.1% between 2008 and 2009.
Greenhouse gas emissions from the industrial processes sector fluctuated slightly in the beginning of the inventory period, then a considerable decline happened: emissions reached their minimum in 1992, which was mainly due to economic crisis. Later on, emissions had been fluctuating again until 2005. Since then, emissions have been showing a decreasing

tendency again and aggregated emissions decreased by 40.7% between 2005 and 2009. *Figure 4.2*. shows the trend of GHG emissions from this category for 1985-2009.

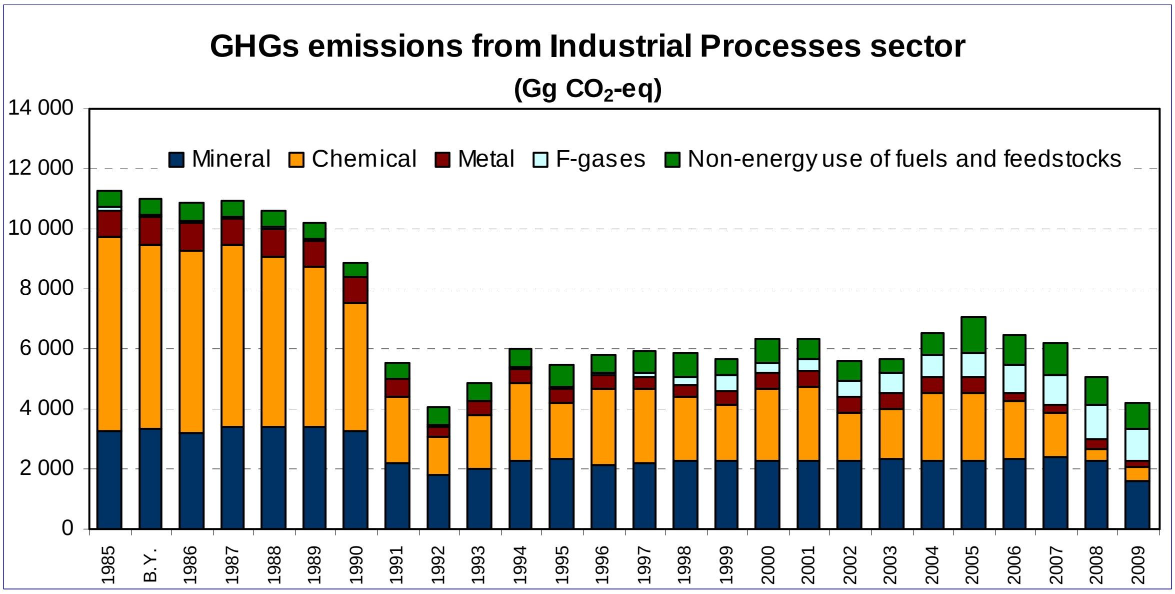

Figure 4.2. *GHGs emissions from Industry sector, 1985-2009 (Gg CO_2-eq)*

The significant decrease of emissions in the period between 1989 and 1993 is strongly represented in the above figure. The reason for that is the economic transition mentioned already in previous chapters. In the course of transition, factories were closed down, capacity utilization was reduced, consequently the production decreased more or less drastically in each industrial sector.

Some examples:

- Iron and steel production: two out of three plants were provisionally closed down;
- Aluminium: two out of three plants were closed down in 1991 and the aluminium production stopped in 2006 eventually;
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed down (1988, 1991 and 1995).

The privatization was slower in the industry than in other areas of the economy. Foreign investments were made rather in medium or smaller sized enterprises than in the big companies of the Hungarian industry.
One of the reasons of temporary production decrease was the modernization process of the remaining factories which was carried out that time and which by the way lead to favourable changes of specific emission factors as well. This was the situation e.g. in the cement and limestone industry. In some cases, however, also plants having more advantageous emission factors were closed, causing unfavorable changes in the national emission factor. This was the situation e.g. in the production of nitric acid before 1995 (see Ch. 4.2.2.).
Since the mid 1990s, emissions by industry have been showing a fluctuating behavior reflecting the actual demands of production in the national economy. An example is the (relatively) significant increase of methane emission, which can be definitely connected to the increase of production in the chemical industry (see e.g. ethylene production: 2004: 374 kt, 2005: 594 kt, 2006:578 kt, 2007:648 kt, 2008:606 kt, 2009:566 kt).

4.2.1. Emission Trends by Gases

The most important GHG in Industrial Processes sector is carbon dioxide, contributing 73.5%

to total GHG emissions in this sector in 2009, followed by hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) contributing 25.6% to GHG emissions (*Figure 4.3*). CH_4 and N_2O contributed 0.6% and 0.4%, respectively. Total sectoral emissions decreased by 61.9% between base year and 2009.

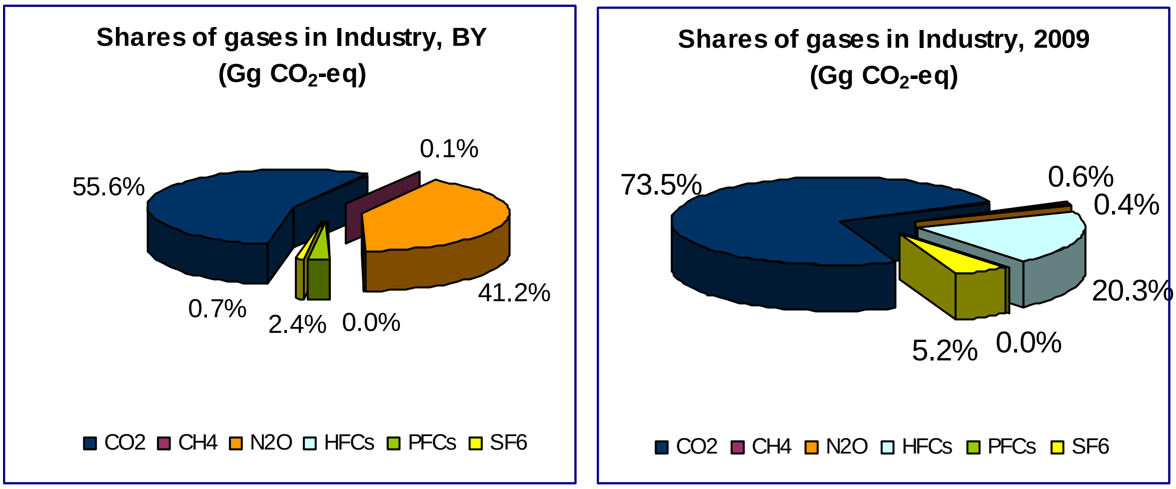

Figure 4.3. *Shares of gases in Industry sector, in base year and 2009 (Gg CO_2-eq)*

The figure below shows the emissions of this sector by gases:

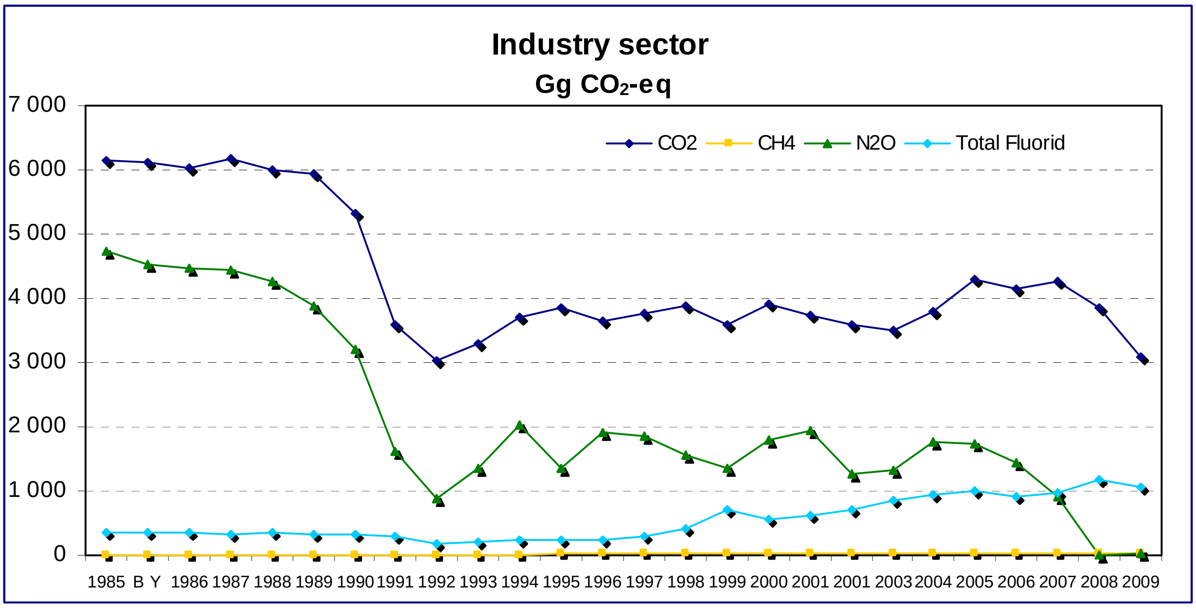

Figure 4.4. *The most significant greenhouse gases in Industry sector. In comparison with them, the quantity of fluoride gases and methane is negligible.* Note: *BY=average of 1985-87 but 1995 for F-gases*

It can be seen in *Figure 4.4* that in 2008, N_2O emission from Industrial Processes are 99.89% below the level of the base year and dropped by 99.44% from 2007 to 2008 which is due to the introduction of a new nitric acid plant.

4.2.2. Emission Trends by sources

In the base year, the chemical sub-sector accounted for 55.9% of total industrial GHG emissions, followed by mineral sub-sector 30.1%, metal sub-sector 8.3%, feedstocks and non energy use of fuels 5.0% and F-gases 0.7%. In 2009 mineral sub-sector accounted for 38.5% followed by F-gases 25.6%, feedstocks and non energy use of fuels 20.4%, chemical sub-sector 11.3% and metal sub-sector 4.3% (see Figure 4.5 and *Table 4.1*.).

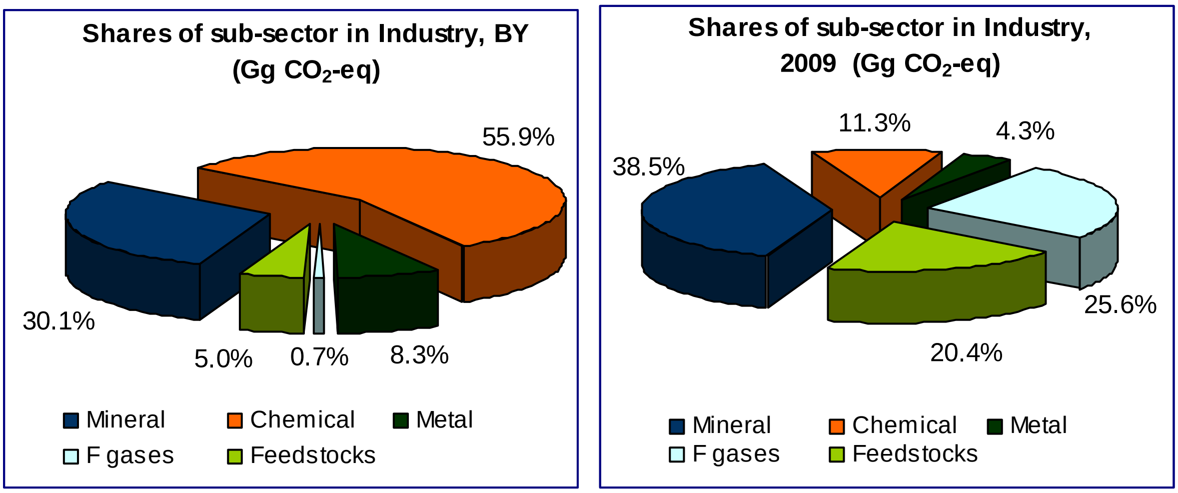

Figure 4.5. *Shares of sub-sectors in Industry sector, in base year and 2009 (Gg CO_2-eq)*

Table 4.1*. Emissions of Industrial processes sector in 2009, (CO_2-eq)*

	GHG emissions in 2009 (Gg CO_2-eq)				
	CO_2	CH_4	N_2O	$HFC/PFC/SF_6$	Total
2. Industrial Processes	**3082.53**	**25.64**	**14.81**	**1072.68**	**4195.66**
A. Mineral products	1614.59	0.00	0.00	0.00	1614.59
B. Chemical Industry	432.63	25.64	14.81	0.00	473.08
C. Metal Production	180.44	0.00	0.00	0.00	180.44
D. Other Production	0.00	0.00	0.00	0.00	0.00
E. Production of $HFC/PFC/SF_6$	0.00	0.00	0.00	0.00	0.00
F. Consumption of $HFC/PFC/SF_6$	0.00	0.00	0.00	1072.68	1072.68
G. Other	854.87	0.00	0.00	0.00	854.87

Figure 4.6. presents greenhouse gas emissions from Industrial Processes by sub-categories for the years 1985 to 2009. Chemical industry was the most important emitter in the beginning of the inventory period, especially N_2O emission from nitric acid production (for details see there). Nowadays the main source of greenhouse gases is Mineral Products while Consumption of Halocarbons and SF_6 is also showing a growing tendency.

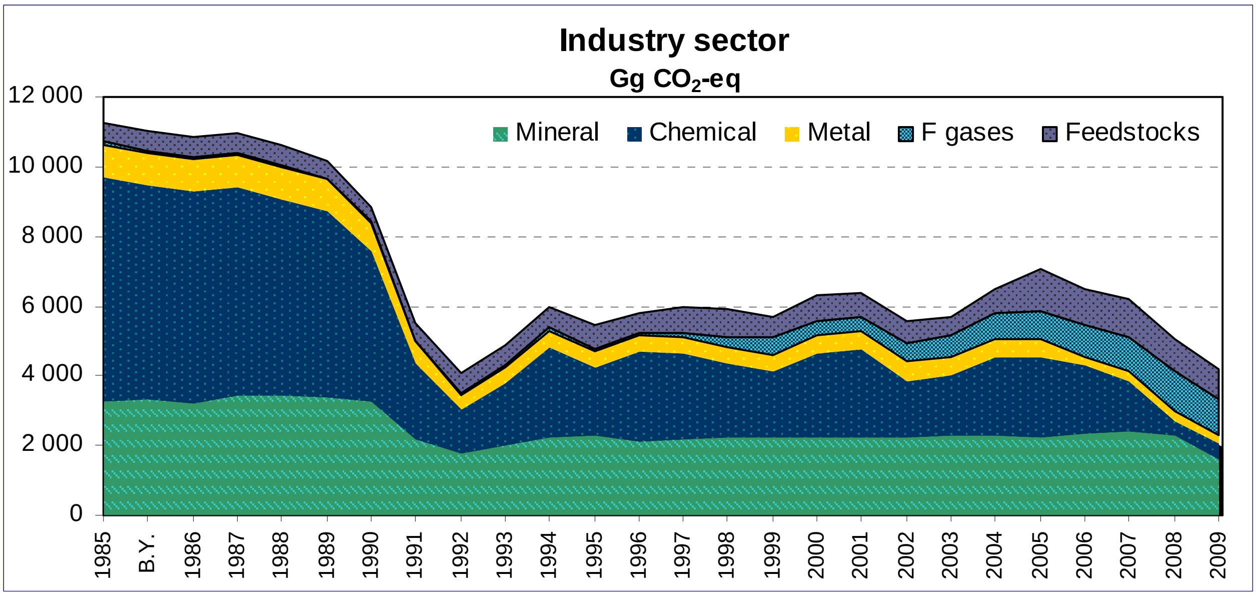

Figure. 4.6. *The emissions in Industry by sub-sectors*
Note: BY=average of 1985-87 but 1995 for F-gases.

4.3. Mineral Products (CRF sector 2.A)

4.3.1. Cement Production (CRF sector 2.A.1)

4.3.1.1. Source category description

Emitted gas: CO_2, SO_2
Key source: Level: Cement production, CO_2

CO_2 is generated during cement production in the clinker production phase:

- on the one hand, during the combustion of the fuels used,
- on the other hand, during the degradation of the limestone ($CaCO_3$) fed into the furnace, which occurs at around 1,300ºC and results in CaO (Calcium Oxide) and CO_2 (calcinations).

$$CaCO_3 + heat \rightarrow CaO + CO_2$$

The raw materials may contain other carbonate minerals (e.g., $MgCO_3$). Both dry and wet technologies may be used for the preparation of the raw clinker. Wet technology is used by one of the four cement production plants in Hungary.

4.3.1.2. Methodological issues

In this category, only emissions from the production processes are determined. Gases originating from fuels are included in Energy sub-sector 1.A.2.B Non-Ferrous Metals.
Emissions were estimated using a country specific method similar to the IPPC Tier 2 methodology. In 2009 four factories were operating in Hungary. Production data for the whole time series were obtained directly from the factories and from the EU Emission Trading System (ETS)
According to the ETS introduced by the European Union from 2005 on, the factories report their CO_2 emission. This value is calculated on the basis of the derivatographic analysis of carbonate, which contains also CO_2 generated from the $MgCO_3$ content of limestone. All

these increase the accuracy of emission-determination. The reported quantities of CO_2 emitted between 2005 and 2009 are based on reports of the factories.
For the preceding years, raw material consumption was used for emission calculation instead of cement or clinker production. This is more accurate because cement factories measure the amount and composition of the raw flour. In 2000, production at one site was abandoned therefore previous production data of this factory were obtained directly from the Cement Industry Association that supplied only clinker data and the ratio of calcium-oxide to clinker. The table below shows the time-series of production data.

***Table 4.2**. Amount of raw flour used in process, clinker and cement production (kt) in Hungary (1985-2009)*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
Raw, kt	5,151.8	5,148.0	3,247.3	2,533.2	3,009.6	3,476.5	3,493.0	3,274.8	3,463.0	3,603.0
Clinker, kt	3,173.2	3,210.4	2,067.3	1,591.3	1,906.7	2,211.0	2,214.2	2,034.0	2,184.8	2,262.1
Cement, kt	3,888.9	3,932.8	2,563.2	2,245.6	2,521.3	2,795.3	2,874.9	2,745.0	2,806.2	2,995.1
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Raw, kt	3,998.1	4,008.5	4,218.3	4,209.1	3,828.2	3,578.8	3,884.3	3,938.7	3,747.0	2,889.3
Clinker, kt	2,531.8	2,522.0	2,687.1	2,696.1	2,494.8	2,352.6	2,533.1	2,577.1	2,468.4	1,883.0
Cement, kt	3,348.2	3,452.4	3,504.2	3,564.9	3,266.7	3,363.5	3,722.9	3,485.1	3,569.8	2,808.5

Upon receiving information on the carbonate content of the raw flour from the producers and the carbonate content of clinker from the Association, the quantity of CO_2 was calculated using the proper stoichiometric proportions. On a similar way we calculated also the amount of CO_2 generated from $MgCO_3$ using the corresponding stoichiometric ratio. The results were corrected for cement kiln dust (CKD) in the case of wet technology only. Information on amount and carbonate content of dust released through the stack and separated by the separators were all provided by the operator. In the plants using dry technologies, the entire quantity of stack dust is recirculated into the furnace.

***Table 4.3.** CO_2 emission in 2.A.1 Cement Production sub-sector (1985-2009)*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
CO_2 from $CaCO_3$, kt	1,724.0	1,752.1	1,098.0	857.2	1,019.6	1,178.3	1,182.9	1,108.6	1,171.8	1,216.7
CO_2 from $MgCO_3$, kt	54.3	45.2	28.5	26.5	31.5	36.2	35.9	34.8	36.2	36.4
Total CO_2, kt	1,741.4	1,797.3	1,126.5	883.7	1,051.1	1,214.6	1,218.8	1,143.3	1,208.0	1,253.1
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 from $CaCO_3$, kt	1,353.9	1,365.0	1,434.8	1,404.8	1,291.0	---	---	---	---	---
CO_2 from $MgCO_3$, kt	41.0	42.7	42.4	47.5	49.6	---	---	---	---	---
Total CO_2, kt	1,395.0	1,407.6	1,477.2	1,452.4	1,340.6	1,198.9	1,295.9	1,328.1	1,260.6	972.7

Due to the CO_2 generated from $MgCO_3$, which was calculated in 2007 for the first time for the whole time series, the earlier specific factors increased by nearly 5%. Upon the recommendation of ERT, we supplemented the emission calculation by carbon dioxide generated from $MgCO_3$. According to the information obtained from the Cement Industry Association, the limestone used in cement production contains very few, not more than 1-5% $MgCO_3$. The $MgCO_3$ content (in MgO) of raw flour was received for years 2002-2006 for each factory. The data of earlier years were calculated by averaging these data.

Accordingly, average emission factors were obtained using CO_2 emissions calculated for the individual factories and production data. These are shown in the table below. In addition, the table demonstrates the time series of the annual emissions[1]:

Table 4.4. *Specific emission factors of clinker and cement in 2.A.1 Cement Production sub-sector (1985-2009)*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
CO_2/ clinker	0.5604	0.5598	0.5449	0.5553	0.5513	0.5493	0.5505	0.5621	0.5529	0.5539
CO_2/ cement	0.4573	0.4570	0.4395	0.3935	0.4169	0.4345	0.4239	0.4165	0.4305	0.4184
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
CO_2/ clinker	0.5510	0.5581	0.5498	0.5387	0.5374	0.5096	0.5116	0.5153	0.5107	0.5166
CO_2/ cement	0.4166	0.4077	0.4216	0.4074	0.4104	0.3565	0.3481	0.3811	0.3531	0.3463

The default factor is 0.5071 t/t for clinker (with a CaO content of 65%), and 0.4985 for cement (Revised Guidelines). The higher specific CO_2 emission of clinker is due to the higher $CaCO_3$ content of raw flour which results in better clinker quality. This enables the higher content of additives in cement and lower emission factors.

4.3.1.3. Uncertainties and time-series consistency

Based on the information obtained from factories, the following uncertainties are associated with the data:

Uncertainty of raw material use data:	0.2 % to 1 %
Uncertainty of the carbonate content of raw material:	0.2 % to 4 %
Estimated total:	2.1%

On the basis of the information in the Good Practice, the following uncertainties are associated with the calculation of the emissions of cement production processes:

Production data:	1 % to 2 %
Total carbonate content of the raw flour:	1 % to 3 %
Amount and composition of stack dust (CKD):	5 %
Estimated total[2]:	2.5 %

The originally small uncertainty was further improved by using data of Emission Trade System. Due to different measuring approaches before and after 2005, the consistency of the time-series shall be verified.

4.3.1.4. Source-specific QA/QC information and verification

The data used for emission calculations were obtained directly from the factories. Each factory has a quality assurance system in compliance with any of the ISO 9000 series. It should be noted that no such systems were operated in Hungary in the beginning of the 1990's.

The Cement Industry Association also verified the raw data and the calculation method. The data received from the Association and those published by KSH show a difference of a few thousand tons.

[1]The national total emission was calculated by summing the emissions of individual factories instead of using the average of the specific emissions.

[2] Taking into consideration that although the highest uncertainty is associated with CKD, it affects a negligible proportion of the production volume.

The resulting national emission factors were compared to the default values recommended by the Revised Guidelines (0.4985 t/t for cement). This showed that the Hungarian specific factors are by about 20 % lower than the default value. This difference is attributable to the use of high amounts of additives, as mentioned above.
In case of wet process, where part of the CKD is removed from the system, this was taken into consideration on the basis of the residual $CaCO_3$ content of the CKD.

4.3.1.5. Source-specific recalculations

Last year there was no recalculation.

4.3.1.6. Source-specific planned improvements

None.

4.3.2. Lime Production (CRF Sector 2.A.2)

4.3.2.1. Source category description

Emitted gas: CO_2
Key source: Level and Trend: Lime production, CO_2

This sub-sector includes quicklime production by limestone heating. During the heat transfer, the following reaction occurs:

$$CaCO_3 = CaO + CO_2$$

Here, only CO_2 is generated according to this formula. CO_2 generated by firing processes is accounted under the Energy sector in Manufacturing Industries and Construction (1.A.2.B).

4.3.2.2. Methodological issues

The amount of CO_2 generated by this sub-sector was calculated according to the method recommended by the Revised Guidelines. The emissions were calculated using the production data received from the manufacturers and the proper stoichiometric ratio (0.785). Naturally, the corresponding stoichiometric ratio was used for slack lime ($Ca(OH)_2$) production data as well.

4.3.2.3. Uncertainties and time-series consistency

According to the data provided in the Good Practice, the uncertainty of the emission calculations for the recent years is estimated to 5 %. The uncertainty of calculations for the initial years is higher than that. As a result of uniform calculation method, time-series consistency is ensured.

4.3.2.4. Source-specific QA/QC information and verification

The data were received directly from the operators which increased the reliability of the information.

4.3.2.5. Source-specific recalculations

Last year there was no recalculation.

4.3.2.6. Source-specific planned improvements

None.

4.3.3. Limestone and Dolomite Use (CRF sector 2.A.3)

4.3.3.1. Source category description

Emitted gas: CO_2
Key source: Level: Limestone and dolomite use, CO_2

This sub-sector includes processes in which calcinations (CO_2 loss) occur as a result of heating limestone and dolomite, but excluding their use in cement and lime production. Here, only CO_2 emissions generated by the degradation reaction are calculated while gases from fuel combustion are included in sub-sector 1.A.2.B.

4.3.3.2. Methodological issues

The emissions were calculated according to the Revised Guidelines and using the correct stochiometric ratios. Identification of the activity data was complicated by the fact that the national data published by KSH also include other uses of limestone and dolomite (e.g., road construction). Since the emissions from most of the limestone used for purposes other than construction were already taken into consideration in the previous calculations, only limestone and dolomite used during various phases of iron production and limestone quantities used during the separation of sulphur were calculated here. These values were obtained on the basis of the data received from the manufacturers. For those years when such data were not available, the default value (250 kg dolomite/t iron) was used. Separation of sulphur has been carried out in one power plant since 2002 and in two since 2004.

4.3.3.3. Uncertainties and time-series consistency

According to the information obtained directly from the factory, the reliability of the data is relatively high and the estimated uncertainty of the emissions is 2 %. For years when the default values were used, the uncertainty is higher.

4.3.3.4. Source-specific QA/QC information and verification

No sector-specific information is available.

4.3.3.5. Source-specific recalculations

Last year there was no recalculation.

4.3.3.6. Source-specific planned improvements

None.

4.3.4. Glass Production (CRF sector 2.A.7.1)

4.3.4.1. Source category description

Emitted gas: CO_2
Key source: Trend: Mineral products Other, CO_2

Although glass production is mentioned in the Revised Guidelines as a source of NMVOC only, also CO_2 emission from glass production was determined based on the data from the Emission Trading System. CO_2 emission is generated by adding the carbonates (mainly soda ashes) of the alkali metals (Ba, Li, Na, etc.) to the melt in the course of glass melting.

4.3.4.2. Methodological issues

Considering the fact that all the glass factories take part in the emission trade, the quantity of CO_2 reported by them was accepted as emissions between 2005 and 2009. The data of total

produced quantity were provided by the HCSO. The CO_2 emission is only 53.97 Gg representing only 0.1% of the total CO_2 emission. In order to achieve time-series consistency, we supplemented the inventory with data of earlier years as well. A specific emission factor was created from the emission trading data of 2005, and emissions were calculated retrospectively using this EF with the known production data.
This method gives quite rough estimates for the earlier years as it does not consider the different carbonate content of the raw materials necessary for the various glass types. Nevertheless, due to its small rate, it has no demonstrable effect on the whole inventory.

The *Figure 4.8* below shows the complete CO_2 emission from this category:

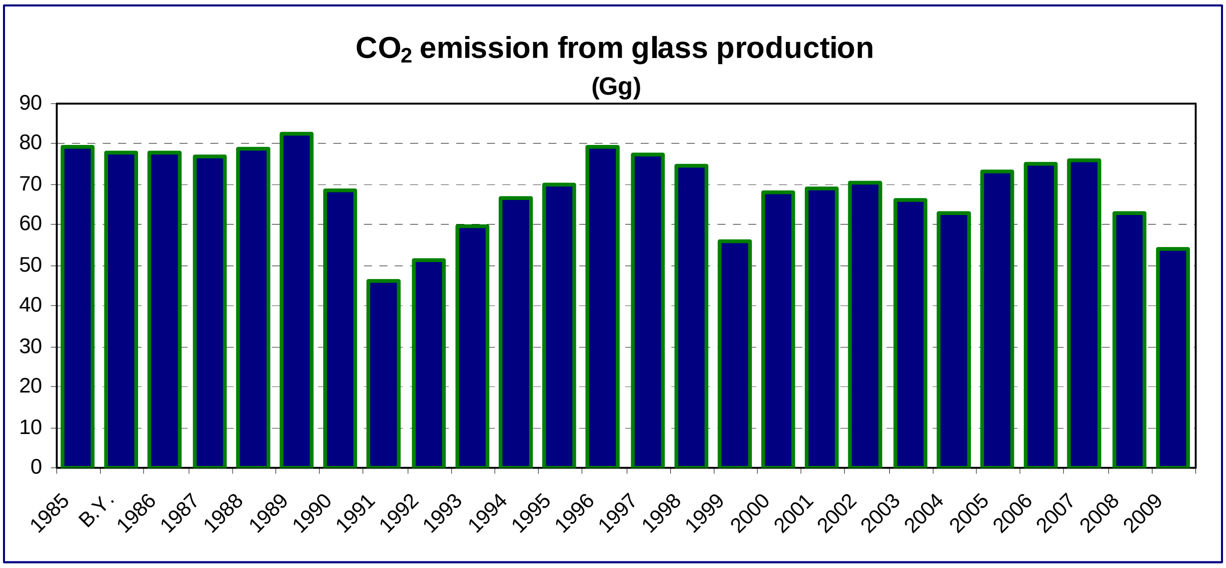

Figure 4.7. *CO_2 emission from Glass Production (1985-2009)*

The ERT noted that the time-series consistency between 1985-2005 and 2006 is not fully ensured by this calculation method, therefore recommended to make further efforts to improve time-series consistency. We have compared the CO_2 emission from ETS data with the emissions calculated with our country-specific factor and we have received the following results (*Table 4.5*):

Table 4.5. *CO_2 emission comparison, Gg*

	2006	2007	2008	2009
CO_2 emission from ETS, Gg	**75.275**	**76.147**	**62.980**	**53.970**
Country-specific IEF-2005, Gg	**68.050**	**71.781**	**73.593**	**65.985**
Difference, Gg	**7.225**	**4.366**	**-10.612**	**-12.015**

CO_2 emission from ETS was higher in 2006 and 2007 by 10.62% and 6.08%, respectively but lower in 2008 and by 14.42%and 18.21%. The lower value was due to the new data logging methodology of the HCSO, i.e. estimations were made from salesmanship.

4.3.4.3. Source-specific QA/QC information and verification

No sector-specific information is available.

4.3.4.4. Source-specific recalculations

Last year there was no recalculation.

4.3.4.5. Source-specific planned improvements
None.

4.3.5. Bricks and ceramics (CRF sector 2.A.7.Other)

4.3.5.1. Source category description
Emitted gas: CO_2
Key source: Trend: Mineral products Other, CO_2

Similarly to glass production, brick and ceramics production was put in the system also on the basis of emission trade information. During manufacturing of these products, CO_2 emission is generated from the degradation of carbonates in the raw materials on the one hand, and from burning of materials added to bricks on the other.

4.3.5.2. Methodological issues
The same method was used to determine emission as in case of glass production with the difference that not all the participants of the sector take part in emission trade. Thus, the reported CO_2 emission does not cover the whole sector. Thus, we calculated a specific emission factor on the basis of the values given in the trade system and applied this to the total produced quantity known from statistical data. With the help of this factor, the emission of the earlier years was also calculated. The emission in 2009 was 110.18 Gg which is 0.2 % of the total CO_2 emission. The following table contains the data of production and emission:

Table 4.6. *Bricks and ceramics production and CO_2 emission in Industry sector (1985-2009)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bricks and ceramics, kt	6,339.6	6,275.8	4,509.4	3,500.9	3,978.9	4,207.6	4,784.3	4,217.0	4,222.7	4,437.6
CO_2 Gg	536.6	557.1	400.3	310.8	353.2	373.5	424.7	374.3	374.8	393.9
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bricks and ceramics, kt	3,021.9	2,728.3	2,300.4	3,018.6	3,277.1	3,763.0	3,817.0	4,841.0	2,962.8	622.2
CO_2 Gg	268.2	242.2	204.2	267.9	290.9	334.0	360.5	357.6	312.0	110.2

4.3.5.3. Uncertainties and time-series consistency

4.3.5.4. Source-specific QA/QC information and verification
No sector-specific information is available.

4.3.5.5. Source-specific recalculations
Last year there was no recalculation.

4.3.5.6. Source-specific planned improvements
None.

4.4. Chemical Industry (CRF sector 2.B)

The relevant processes operated in Hungary include:

- Ammonia production
- Nitric acid production
- Production of other chemicals: carbon black, ethylene and dichloroethylene.

Production of the chemical industry increased in 2009 compared to 2008 by 10.63%. This is demonstrated by the time series of the production data in the tables shown later and in the next figure.

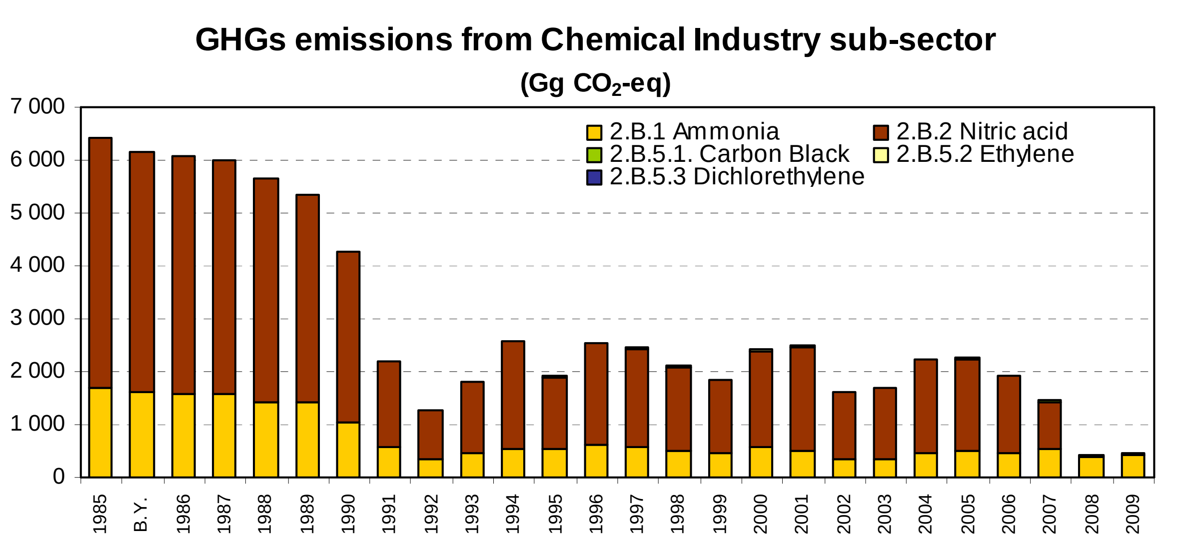

Figure 4.8. *Total emission from Chemical sub-sector (1985-2009)*

4.4.1. Ammonia Production (CRF sector 2.B.1)

4.4.1.1. Source category description

Emitted gas: CO_2
Key source: Level and Trend: ammonia production, CO_2

Traditional ammonia (NH_3) production uses natural gas whose carbon content is released by the system in the form of carbon dioxide. Here, only emissions from the natural gas used as raw material is calculated and emissions from firing processes are taken into consideration under sub-sector 1.AA.2.C. Out of the factories operating in 1985, one was abandoned in 1987, another in 1991, and a third in 1992.
As regards existing factories, one uses obsolete technology and the other changed to a hydrogen/nitrogen-based technology in 2002. This technology does not generate technological CO_2. Hydrogen is produced in another chemical plant from natural gas and the resulting CO_2 emissions are reported under Energy sector. The share of the latter in the production is about only 5 %.

4.4.1.2. Methodological issues

Initially, production data published by KSH and default value recommended by the Revised Guidelines (1.5 to CO_2/t ammonia) were used for calculations. During ERT reviews (2002), it was repeatedly noted that calculation based on ammonia produced is not sufficiently accurate and natural gas-based calculations are more reliable, as also recommended in the first place by the Revised Guidelines. Therefore, we contacted the factories and the

emissions were subsequently calculated using the natural gas consumption data obtained from them. According to the recommendation of ERT in 2007, we indicated the natural gas quantity instead of the previously used ammonia production in the CRF Reporter. Since the input of the natural gas quantity in cubic metres was not possible, it was given in tons.
The table below shows the amount of the used natural gas and the resulting emission data:

***Table 4.7**. Amount of natural gas used in the process, CO_2 emission and IEF tCO_2/tNH_3 in Chemical sub-sector (1985-2009)*

	BY	1990	1992	1993	1994	1995	1996	1997	1998	1999
Natural gas, kt	685.86	432.05	148.92	186.69	222.47	223.70	247.69	237.39	212.17	191.94
CO_2, Gg	1,676.33	1,056.00	363.97	456.30	543.74	546.74	605.39	580.21	518.56	469.13
IEF CO_2 (t/tNH_3)	1.76	1.67	1.61	1.57	1.49	1.45	1.43	1.41	1.48	1.48
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Natural gas, kt	241.86	212.31	144.30	143.54	184.74	208.03	195.59	213.77	160.91	177.01
CO_2, Gg	591.14	518.92	352.70	350.84	451.52	508.44	478.05	522.47	393.28	432.63
IEF CO_2 (t/tNH_3)	1.38	1.32	1.32	1.34	1.29	1.28	1.29	1.28	1.34	1.28

The *Table 4.7* above indicates that tCO_2/tNH_3 IEF value is between 1.28 and 1.76.

4.4.1.3. Uncertainties and time-series consistency

Given that the amount of natural gas used in the process is easy to measure and therefore the emissions can be easily calculated using the proper stoichiometric ratio the estimated uncertainty of the resulting values is low (2 % to 3 %). Consistency is guaranteed.

4.4.1.4. Source-specific QA/QC information and verification

The quality and reliability of the emission data were greatly improved by using production data obtained directly from the factories.

4.4.1.5. Source-specific recalculations

The amount of natural gas had to be corrected for the years 1985-1990 because formerly not all natural gas used by Nitrogénművek Corporation was accounted for.

4.4.1.6. Source-specific planned improvements

None.

4.4.2. Nitric Acid Production (CRF sector 2.B.2)

4.4.2.1. Source category description

Emitted gas: N_2O, (CO_2)
Key source: Trend: Nitric acid production, N_2O

Nitric acid (HNO_3) is produced by oxidizing ammonia. The process end gas contains N_2O and NO_X. In order to control the emissions, the latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide.
Among the old factories using obsolete technologies, one was abandoned in 1988, another in 1991, and a third in 1995. Until 2006 two production lines were operated in the country – the older one was established in 1975 and used GIAP technology which consists of four units with four different factors. These four units represented the major part (about 80%) of the production volume. Emissions from this process were measured from 2004. The other existing technology represented only 20% and had been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid).

Implementation of a new and more advanced production technology was started in 2005, in the framework of a joint implementation project, and it was installed in September 2007. At the same time the old production lines were closed down. Now a state-of-the-art technology is used, therefore drastic emission reduction is reported in this inventory (see *Table 4.8*).

4.4.2.2. Methodological issues

Measured emission data were not available for a long time. Therefore, during the first phase of the recalculation project, the default specific emission factor recommended by IPCC (6 kg N_2O/t nitric acid) was used.
In 2004, an emission measurement system was installed at one of the factories and this has resulted in fundamental changes in the previously estimated values. Therefore, on the basis of almost one year of experience with measurements, the calculated emission factors of the factories using different technologies were between 10 to 19 kg/t. For calculation of emissions of the oldest factory (established in the 1950's), which was abandoned in 1988, the highest value recommended by the Good Practice was used (19 kg N_2O/t). 14.5 kg/t was used as specific emission factor for the three other abandoned factories including the one which was abandoned in September 2007. For the combined factory, a value of 10 kg/t was used.
End of 2004, selective catalytic reduction was introduced in tail-gas treatment which led to emission reductions in the following years. This modernization means furthermore that the EFs before and after 2004 cannot be the same. The emission data of 2005 and 2006 are based on measurements. In the second half of 2005 a new measuring instrument was installed which might partly explain the difference between IEFs. Thus, the weighted average ranges between 10.01 and 14.51 kg/t in the time series, depending on the production volume. In 2007 EF was 6.15 kg/t , 0.0425 kg/t in 2008 and 0.108 kg/t in 2009. The new factory applies the EnviNOx technology consequently a drastic reduction of emission has been reached. N_2O emission from nitric acid production was decreased by 99% between base year and 2009.
The amount of carbon dioxide generated during the reduction reaction is so low (a few tens of tons: max. 93.29 in the whole period; and 63.84 in 2003) that it has no detectable effect on the inventory as a whole. Nevertheless, following the recommendation of ERT, we supplemented the database with these emissions. Since 2004 process tail gas has been treated with ammonia, so CO_2 emissions are no longer an issue. From 2007, further information about consumption of natural gas data was received from the factory. This was used in a new plant as a tail gas reducing agent. Production data were obtained from the factories for each of the 24 years in the time series. These and the emission data are shown in the table below:

Table 4.8. *Nitric Acid production (kt) and N_2O emission in Chemical sub-sector (1985-2009)*

	BY	1990	1992	1993	1994	1995	1996	1997	1998	1999
Nitric Acid, kt	1,013.09	732.35	210.55	310.34	460.11	310.28	453.83	433.53	354.44	309.50
N_2O, Gg	15.26	10.37	2.87	4.34	6.56	4.35	6.21	5.98	5.02	4.40
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nitric Acid, kt	415.99	454.27	294.80	306.21	415.01	484.41	460.83	474.91	385.96	440.01
N_2O, Gg	5.79	6.29	4.04	4.27	5.70	5.59	4.61	2.92	0.02	0.05

EnviNOx technology

The EnviNOx process is usually located between the final tail gas heater and the tail gas turbine and contains two catalyst beds filled with iron zeolite catalysts operating at the same

pressure and temperature and a device for addition NH_3 between the beds. In the first DeN_2O stage, the N_2O abatement is effected simply by the catalytic decomposition of N_2O into N_2 and O_2. Since NOx content of the tail gas promotes the decomposition of N_2O, the required DeNOx stage is arranged downstream of the DeN_2O stage.
In the second stage, NOx reduction is carried out using NH_3 as a reducing agent similar to natural gas.
Reactions in the DeN_2O:

$$2\,N_2O + 2NO \longrightarrow 2\,N_2 + 2\,NO_2$$
$$2\,N_2O \longleftrightarrow 2\,NO + O_2$$

$$2\,N_2O \longrightarrow 2\,N_2 + O_2$$

Reactions in the DeNOx:

$$6\,NO_2 + 8\,NH_3 \longrightarrow 7\,N_2 + 12\,H_2O$$
$$4\,NO + O_2 + 4\,NH_3 \longrightarrow 4\,N_2 + 6\,H_2O$$

4.4.2.3. Uncertainties and time-series consistency

The level of uncertainty was significantly improved as a result of using data obtained directly from the factories and introducing an emission measurement system in the technology. The estimated uncertainty of the production data is 2 % to 3 %, while that of the emission factor is much less favourable, i.e., between about 30-40 %, however, this value is estimated to decrease to about 10% by 2005 due to direct measurements.

4.4.2.4. Source-specific QA/QC information and verification

The data received directly from factories greatly improved the quality of data. This is of particular importance, because in the past only limited production data could be obtained from KSH (due to confidential technologies).

4.4.2.5. Source-specific recalculations

From 2007, information about consumption of natural gas data was received from the factory. This was used in a new plant as a tail gas reducing agent. The amount of released carbon dioxide are estimated from the carbon content which provided by IPCC Guidelines (1997)

4.4.2.6. Source-specific planned improvements

None.

4.4.3. Carbon Black (CRF sector 2.B.5.1)

4.4.3.1. Source category description

Emitted gas: CH_4
Key source: NO

4.4.3.2. Methodological issues

Their contribution to the total emission is extremely low. Earlier, the carbon black process was a confidential technology because only one such process was operated in Hungary. Therefore, we could not calculate the related emissions. In 2005 we contacted the manufacturer and obtained production data and an emission factor characteristic of this technology. Accordingly, the factory established in 1993, is working with furnace black process with the thermal treatment of the generated gas. Thus, the emission of methane is quite minimal. The factory had the methane emission measured, and as a result the value of the emission factor was 0.0037 kgCH_4/t product, in 2010 ERT recommended the use of default factor, which is 11 kg CH_4/t carbon black.

4.4.3.3. Source-specific QA/QC information and verification

No sector-specific information is available.

4.4.3.4. Source-specific recalculations

Due to the recommendation of the ERT in 2010, methane emissions from carbon black production were recalculated with the default factor.

4.4.3.5. Source-specific planned improvements

None.

4.4.4. Other chemicals (CRF sector 2.B.5)

4.4.4.1. Source category description

Emitted gas: CH_4 , NMVOC
Key source: NO

This sector includes the following technologies characterized by the following specific emission factors:

- Ethylene: 1 kg CH_4/t ethylene
- Dichloroethylene: 0.4 kg CH_4/t dichloroethylene

4.4.4.2. Methodological issues

Their contribution to the total emission is extremely low. Therefore, they are dealt with as one group. Using production data obtained from KSH and default values recommended by IPCC, methane emission was calculated for these two processes. In 2009, this value was only 0.649 Gg (0.01 %). Comparing to the data of the previous years (0.23-0.78 Gg), the effect of production decrease by ~10% in 2009 can be observed here as well.
Similarly, based on data obtained from the statistical office and using IPCC default values, also NMVOC emission was calculated for the other processes, for example pesticide production, ethylene, dichloroethylene, propylene. In 2009, these emissions amounted to 7.95 Gg.

4.4.4.3. Source-specific QA/QC information and verification

No sector-specific information is available.

4.4.4.4. Source-specific recalculations

There was no recalculation.

4.4.4.5. Source-specific planned improvements

None.

4.5. Metal Production (CRF sector 2.C)

4.5.1. Iron and Steel Production (CRF sector 2.C.1)

4.5.1.1. Source category description

Emitted gas: CO_2
Key source: NO

In this sub-sector, gases emitted by the iron/steel industry (sinter, iron and steel production) are calculated. During sintering (agglomeration), a mixture of iron ore, coke or carbon and limestone are agglomerated by heat transfer to obtain a material suitable for feeding into the furnace. During iron production, coke and carbonate-containing slag-forming additives are added to the agglomerated ore, and the mixture is reduced at a high temperature. This reaction releases CO and CO_2. Therefore, CO_2 is produced from two sources during the process: 1) from fuel, which also serves as a reducing agent, and 2) from carbonate-containing slag-forming agent (limestone or dolomite).
During steel production, the carbon content of iron is reduced from 4-5% to below 1%. Also this is released in form of CO_2. Carbonate-containing iron ores are not used in Hungary. Therefore, we did not calculate such emissions.

4.5.1.2. Methodological issues

Partly for reasons related to the Hungarian traditions of energy statistics, the emissions of the sector from fuels are not included here but in sub-sector 1.A.2.A. The other reason justifying the use of this method is that no information is available as regards the distribution of fossil materials between use as a heat generator (i.e., energy production) and as a reducing agent (i.e., industrial process) during iron production. CO_2 released from limestone and/or dolomite is taken into account under sub-sector 2.A.3 (Limestone and dolomite use). Iron and steel production data were obtained from the reports of the International Iron and Steel Institute and the similar European agency (EUROFER). Initially, limestone consumption data were calculated on the basis of the default value in the Revised Guidelines. In recent years data received from the factories have been used.
In order to make emission calculations complete, carbon dioxide releases from raw iron and graphite electrode of the electric arc furnace (EAF) during steel production were also calculated here. For these calculations, the following default values were used: carbon content of iron: 4%; carbon content of steel: 0.5%; specific emission of electrode: 5 kg CO_2/t steel. The latter was obviously included only in case of electro steel production. Emissions were calculated using the following formula:

$$CO_2\,(Gg) = \left[\left(\text{Steel produced }(kt) \times \frac{\text{carbon content, iron }(\%) - \text{carbon content, steel }(\%)}{100} \times \frac{44}{12}\right) + \text{electro steel }(kt) \times 0.005\right]$$

4.5.1.3. Uncertainties and time-series consistency

The uncertainty of the emission is considered good since the calculations are based on data obtained directly from factories and associations. The time-series is consistent as the same method was applied each year.

4.5.1.4. Source-specific QA/QC information and verification

There is no sector specific information.

4.5.1.5. Source-specific recalculations

There was no recalculation.

4.5.1.6. Source-specific planned improvements

None.

4.5.2. Ferroalloy Production (CRF sector 2.C.2)

4.5.2.1. Source category description

Emitted gas: CO_2
Key source: NO

Upon smelting alloying additive and iron, together with slag-forming additives, a reduction reaction occurs which results in release of CO_2.

4.5.2.2. Methodological issues

Fuels were included in sector 1.A.2.A. and only technological CO_2 emissions were calculated here. The production data were obtained from the KSH and 3.9 t CO_2/t alloy (ferrosilicon) was used as factor in accordance with the Revised Guidelines. In 1991, this process was abandoned.

4.5.2.3. Uncertainties and time-series consistency

The uncertainty of the estimated emissions is moderate because calculations were based on data other than direct raw material consumption data. The time series is consistent because the same method was used for each year.

4.5.2.4. Source-specific QA/QC information and verification

No sector-specific information is available.

4.5.2.5. Source-specific recalculations

There was no recalculation.

4.5.2.6. Source-specific planned improvements

None.

4.5.3. Aluminium Production (CRF sector 2.C.3)

4.5.3.1. Source category description

Emitted gases: CO_2, PFCs (CF_4, C_2F_6)
Key source: NO

During alumina electrolysis, CO_2 is released from carbon anode. At the same time, fluorinated hydrocarbons are produced from cryolite as a result of anode effect when aluminium oxide concentration is low in the electrolyte of the reduction cell. From the beginning of 2006 this technology is no longer in use.

4.5.3.2. Methodological issues

PFC emissions were calculated using the Tier 2 methodology recommended, among others, by the Good Practice. Production data, including data on the sites already abandoned, were obtained directly from the factories. After the major political changes, two electrolysis plants were abandoned. The resulting changes in the volume of aluminium production (Søderberg process) are shown in the table below:

Table 4.9. *Amount of Aluminium Produced (t)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Aluminium, t	73.75	75.19	75.16	62.88	26.82	27.88	29.65	31.91	33.47	33.71
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Aluminium, t	33.85	34.59	35.29	35.04	34.35	31.78	NO	NO	NO	NO

Measured emission data were not available in the factory. Thus, emissions were calculated using specific emission factors. The amount of emitted CF_4 was calculated by entering the appropriate data into the formula and by multiplying the result by the quantity of crude metal produced. 10 % of this was considered C_2F_6. Accordingly, the time series of CF_4 emission is as follows:

Table 4.10. *CF_4 emission in Aluminium Production 2.C.3 sub-sector (1985-2009)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
CF_4, Gg	36.18	36.50	31.50	18.17	19.64	21.42	22.48	21.48	21.41	23.05
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CF_4, Gg	28.40	26.75	27.19	25.38	26.96	28.01	NO	NO	NO	NO

For each year, emissions were calculated for individual factories and the sum of these is used as annual total. You can found detailed description in ANNEX 3. The specific emission factor increased from the initial value of 0.49 kg/t above 0.8 by 2005. One of its reasons was that the emission factor of the factories, which were closed down in 1991, was more favourable than that of the remaining factory: the specific emission factor changed then from 0.5 to 0.68 kg/t. Due to the out-of-date technology of the factory operating further on, the trend of the specific emission factor shows an increasing tendency. After all, the factory ceased its production in the beginning of 2006. The amount of emitted CO_2 was calculated using the default factor (1.8 t/t) and the known production data.

4.5.3.3. Uncertainties and time-series consistency

The total quantity of produced crude metal is in the order of 10.000 tons and the accuracy of the obtained values is 0.1 t. The resulting uncertainty is below 1%. Whereas the effect numbers are recorded in the factory records, the effect time can be easily measured but is an average value. These are associated with a highly favourable level of uncertainty. According to the Good Practice, the uncertainty of the Slope value is about max. 1%. In summary, the uncertainty of emission values is around 1% to 2 %. Data consistency was ensured by using the same calculation method for the whole time series.

4.5.3.4. Source-specific QA/QC information and verification

The factory operated an accredited quality assurance system. We have seen very well kept production records. The necessary data were given to us from these records. The company could provide data from almost 20 years of production without any difficulty.

4.5.3.5. Source-specific recalculations

Last year there was no recalculation.

4.5.3.6. Source-specific planned improvements

None.

4.6. Other Production (CRF sector 2.D)

In this sector only indirect gases from sub-sectors Pulp and Paper and Food and Drink are reported.

4.7. Production of Halocarbons and SF_6 (CRF sector 2.E)

Halocarbons and SF_6 are not produced in Hungary.

4.8. Consumption of Halocarbons and SF_6 (CRF sector 2.F)

4.8.1. Source category description

Emitted gases: HFCs, PFCs, SF_6
Key source: Level: Consumption of Halocarbons and SF_6 - Refrigeration and air conditioning equipment (2Fa1), HFCs

HFCs (partially fluorinated hydrocarbons) are used in household and commercial cooling equipments (CRF 2.F.1.), during production of foams used in construction/insulation industry (CRF 2.F.2.), in fire extinguishers (CRF 2.F.3), in medical and technical sprays (as propellant gas) (CRF 2.F.4.).
PFCs (fully fluorinated hydrocarbons) are used as solvents or as an ingredient of cooling mixes, but they are rare. No HFCs or PFCs are produced in Hungary and such substances are imported.
HFCs may be released to the atmosphere during the following work phases: filling, refilling, repairing, technical failure, direct use (spray, fire extinguishing).
PFCs were started to be used as an ingredient of cooling mixes in 1997. In 1998 and 1999, significant quantities were also used for adhesive tape production.
SF_6 is also imported and is mainly used as an insulation gas in electrical switchboards. It is further used as intermediate gas in double-glass heat insulation windows and production of optical bodies, etc. In Hungary SF_6 is not used as a cover gas in colored metal foundries.

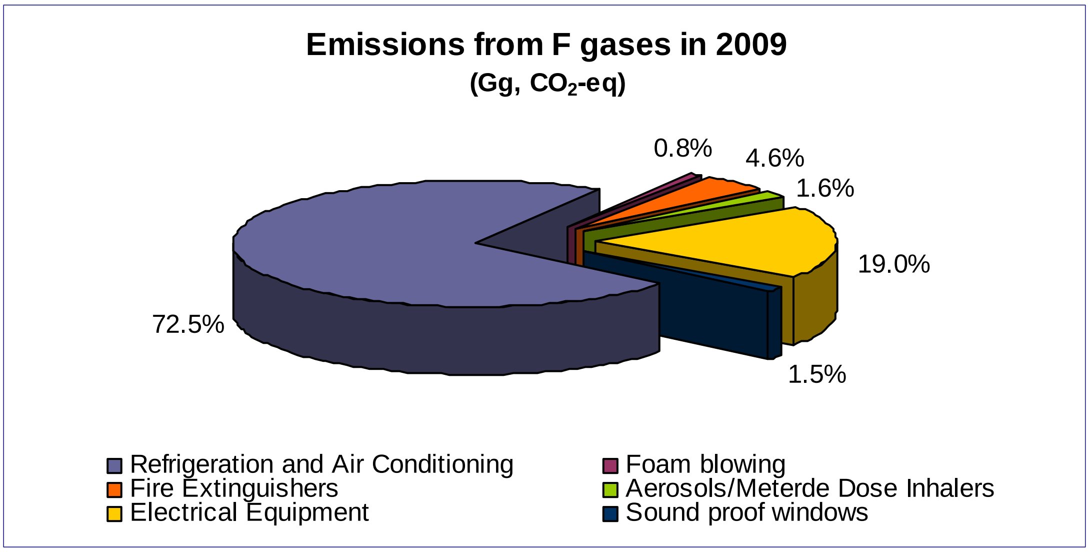

Figure 4.9. *Emission from sub-sectors of F gases in 2009, Gg CO_2-eq*

4.8.2. Methodological issues

In cooling industry, the imported HFCs are either filled into new equipments or are used to refill the cooling medium of installed equipments. It is assumed that the quantities previously released into the atmosphere are replenished and these amounts are taken as the emissions. Naturally, the refilling/handling loss should be added to this. In case of sprays, the entire quantities of propellant used in Hungary are taken as emissions. In the beginning, the emissions were calculated on the basis of a preliminary study prepared by László Gáspár, Institute of Environmental Management in 1998, later the calculations were improved.

Activity data

In the past, import data were obtained from VPOP (National Customs Office and Police). As regards recent years, the data and the uses have been taken into account on basis of the information received from commercial and/or user companies, as well as from the Association of Cooling and Air Conditioning Businesses (HKVSZ). Unfortunately, only a few companies have records on the quantities used for different purposes, and only estimated distributions are provided. The use of HFCs started in 1992, first in household refrigerators. Today, the use of HFCs as a cooling medium is already declining as a result of the ongoing change to R600 (isobutane), which does not have a greenhouse effect. Their use in commercial refrigerators and air conditioning systems, as well as their emission is sharply increasing.

On the basis of the latest available information, HFCs emitted during foam material production were also included. According to data obtained from the factory, the mixture (HFC 227ea/365mfc) is used for the production of both soft and hard foam. HFC-134a is also used in foam material production, and so was HFC-152a in 2006 and 2007.

In calculating the emission of HFCs used in foam blowing for the year 2005, we changed to the method and the specific factors recommended by GPG. The data of 2003 were recalculated with the help of this method. The HFC-365mfc values were taken out of the database and appear now in Cross-cutting information.

In order to calculate domestic consumption, the quantity filled into equipment intended for export was subtracted from the total quantity of HFCs imported.

Emission factors

As regards household refrigerators, emission data were received directly from the manufacturer. In case of commercial and industrial equipment, the data required for determination of quantities used for filling new refrigerators and for refilling existing ones

were received from trading companies. The latter value was taken as emission. As regards production of foam materials, the recommendations of GPG were taken into consideration in calculating emission. The CRF program and the IPCC GWP Table of 2005 do not include GWP for HFC 365mfc, therefore it is not included in the database.
In case of SF_6, consumption and (sometimes) emission data were obtained directly from the users. When a company could not provide data for a given year, this was determined by estimation.

4.8.2.1. 2.F.1 Refrigeration and Air Conditioning Equipment

Emitted gases: HFC-125, HFC-32, HFC-143a, HFC-134a, HFC-152a, HFC-23, C_3F_8

Emission data, export-import data, refilled amount of domestic refrigerators were received directly from the manufacturer from 1992. Initially, the manufacturer used HFC-134a as a chemical charge for the replacement of R12. R600 has been applied from 1994 and its use has been significantly increased. Nowadays, this chemical is used alone.
Fugitive assembly emissions do not occur when the equipments are filled because the system of filling is a closed system.
In case of commercial and industrial equipments, distributors or trading companies were contacted to get information on the quantities used for filling new refrigerators and for refilling existing ones. For certain operators, the filling/refilling ratio was determined by estimation taking into account their activities This refilled amount was taken as emission, i.e. in such cases emissions were calculated without using emission factors.

4.8.2.2. 2.F.2 Foam Blowing

Emitted gases: HFC 134a, HFC-152a, HFC-227ea

HFCs are being used in foam applications such as insulating, cushioning, packaging, the automotive industry, furniture manufacturers, medical appliance and cosmetic industry. Export and import data were obtained from the factories from 2003. The mixture (HFC 227ea/365mfc) is used for the production of both soft and hard foam. HFC-134a is also used in foam material production, and HFC-152a used in 2006 and 2007. The IPCC Guidelines suggest calculating emissions from open-cell foam separately from closed-cell foam.

Open-Cell Foam:

Since HFCs used for open cell foam blowing are released immediately, all of the emissions will occur in the country of manufacture. Emissions are calculated according to the following equation:

Emissions from Open-Cell Foam = Total Annual HFCs Used in Manufacturing Open-Cell Foam

Closed-Cell Foam:

Emissions from Closed-Cell foam occur from the following:

1. First year losses from manufacture, these emissions occur where the product is manufactured.
2. Annual losses (in situ losses from foam use). Closed-cell foam will lose a fraction of their initial charge each year until decommissioning. Since we had no information about decommissioning amount, it was assumed that all chemical not emitted in manufacturing is emitted over the lifetime of the foam.

The applied equation is the following:

Emissions from Closed-cell Foam **=** [(Total HFCs Used in Manufacturing New Closed-cell Foam in year t) • (first-year Loss Emission Factor)] + [(Original HFC Charge Blown into Closed-cell Foam Manufacturing between year t and year t – n) • (Annual Loss Emission Factor)]

The used default assumptions for our calculations are shown in *Table 4.11*.:

Table 4.11. *Default emission factor for HFCs from Closed-Cell foam*

Default emission factor for HFCs from Closed-Cell foam	
Emission Factor	**Default Values**
Product Lifetime	n = 20 years
First Year Losses	10% of the original HFC charge/year
Annual Losses	4.5% of the original HFC charge/year

The equation above was applied to each chemical individually. Total CO_2-eq emissions are equal to the sum of CO_2-eq emissions of each combination of all chemical types. To implement this approach it was necessary to collect current and historical data on annual chemical sales to the foam industry for the period.

4.8.2.3. 2.F.3 Fire Extinguishers

Emitted gases: HFC 125, HFC-227ea

Activity data, mainly import and export data, were obtained directly from the fire protection companies. Currently, our emission calculations are based on the method of potential emissions (Tier1). To our knowledge, PFCs are not used in fire extinguishing equipments and HFCs are applied only in flooding equipments.

4.8.2.4. 2.F.4 Aerosols and Metered Dose Inhalers

Emitted gases: HFC 134a, HFC-152a.

Most aerosol packages contain mainly hydrocarbons (HC) as propellants, but in a small fraction also HFCs are used, especially HFC-134a in industrial applications, and household and medical products.

Emissions from aerosols occur shortly after production, all the initial charge escapes within the first year. Therefore, to estimate emissions, it is necessary to know the total amount of aerosol initially charged in product containers prior to sale. It was assumed that all chemical substances were emitted in the operating systems.

Metered dose inhalers were produced from 1999. Small fraction of the production was used within Hungary, most of them were exported. Technical sprays, like spray duster and freezing spray were manufactured and used from 2000. Information about HFCs was obtained directly from producers or distributors.

4.8.2.5. 2.F.8 Electrical Equipment

SF_6 is also imported and is mainly used as an insulation gas in electrical switchboards. Consumption and some emission data were obtained directly from the users. However, only one company could provide data for the initial years therefore aggregated activity data were determined by estimation up to 1997, taking due account of the general trends of industrial production. When a company could not provide data for a given year, this was determined again by estimation.

4.8.2.6. 2.F.9 Other applications

SF_6 is used in a variety of additional applications including its usage as an insulating medium in sound proof windows. Information of traded gases were obtained from distributors, the calculation formula is based on the basic method (Tier1). Due to lack of accurate information, data for 1992-96 are estimated values, but according to the distributor, these values should be similar to that of 2002.

Potential emission= Import-Export

4.8.2.7. Cross cutting information

HFC-365mfc are F-gases that are not regulated under the Convention; this is why emissions of these gases are not included in national totals, but reported in CRF Table 9(b) as additional GHG.

4.8.3. Uncertainties and time-series consistency

Trading companies, mainly involved in commercial refrigerators, gave estimates on the proportion of the imported HFCs used for refilling that were associated with a high level of uncertainty and the error may be as much as 10 to 20 per cent. As regards household refrigerators, the estimated uncertainty is a few percent. In case of medical sprays, the entire amount of HFC is released into the atmosphere and the associated uncertainty is low. The uncertainty of SF_6 emission may be considered favourable for 2000. However, for the preceding years, it may be rather high and even underestimated. Given that the same method was used for all calculations and the whole time series is available, the data may be considered consistent but are associated with different levels of uncertainty in different years.

4.8.4. Source-specific QA/QC information and verification

Instead of using import quantity data received from VPOP, we changed to using data obtained directly from users, thereby the associated uncertainty was significantly reduced. The company for manufacturing household refrigerators operates a quality assurance system of the ISO 9000 series.

4.8.5. Source-specific recalculations

This year a comprehensive checking was carried out. All activity data has been verified and all calculations from the year 1992 has been updated. The calculation and copying errors were corrected. Besides, new data were added to 2.F.3 Fire Extinguishers sub-sector. This recalculation resulted in an increase of emissions, as shown in *Figure 4.10*.

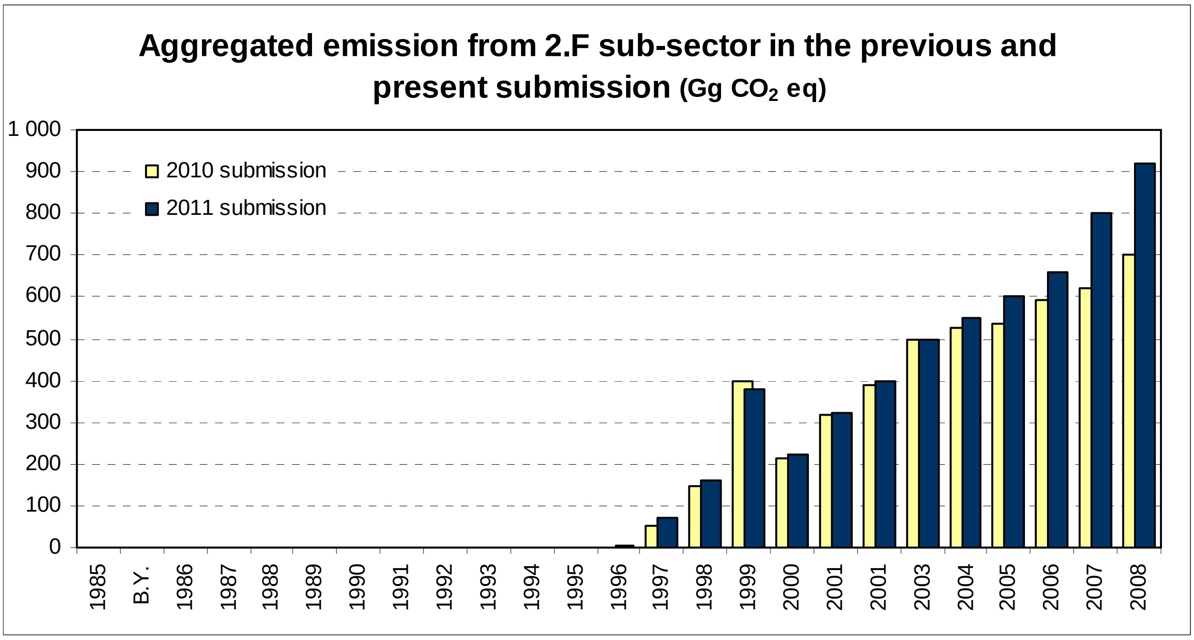

Figure 4.10. *Changes in 2.F. sub-sector (1985-2008)*

4.8.6. Source-specific planned improvements

Further refining of consumption data is planned, primarily as regards the purpose of use in question.

4.9. Other (CRF sector 2.G)

4.9.1. Source category description

Emitted gases: CO_2
Key source: Level and Trend: Feedstocks, CO_2

4.9.2. Methodological issues

This category was created for calculating carbon dioxide emissions from fuels used as feedstock or other non-energy purposes. CO_2 emissions arise from oxidization during use. Methane emissions are expected to be minor or not to occur at all.

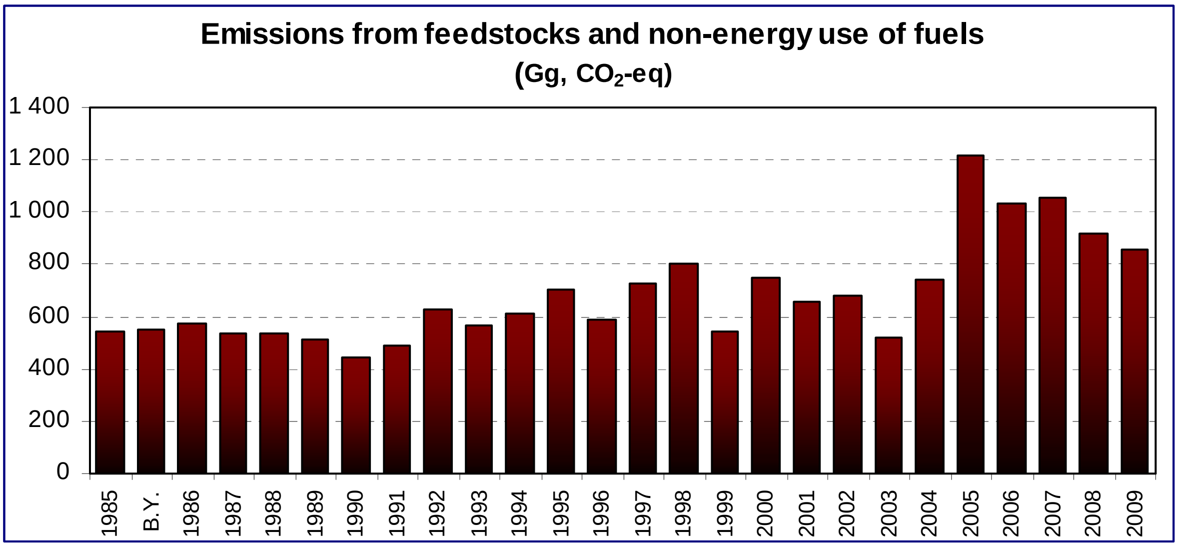

Figure 4.11. *Emission from feedstock and non-energy use of fuels Gg, CO_2-eq*

The use of fossil fuels as feedstock or for other non-energy purposes is reported in an aggregated manner by Energy Statistics under "Non-Energy Use" for each individual fuel. It is an aggregated category because the real consumers of these fuels are unknown. These kinds of oil products are widely used. Just a few examples: paraffin waxes are used for candles, corrugated boxes, paper coating, board sizing, adhesives, food production, packaging; lubricants are consumed in transportation and industry; white spirit, kerosene, some aromatics are applied as solvents e.g. for surface coating (paint) and dry cleaning.

Whenever CO_2 emissions resulting from non-energy fuel use are allocated to another category of the Industrial Processes Sector, those emissions are subtracted from the total non-energy emissions to avoid double counting. For example natural gas used as feedstock in ammonia and nitric acid production, ethylene and carbon black manufacturing is not reported here.

The amount of released carbon dioxide are estimated from the carbon content of fuels and fraction of carbon not stored which are based on figures provided by IPCC Guidelines (1997). Bitumen or asphalt for road paving and roofing is taken into account in the appropriate subsector in industrial processes.

4.9.3. Source category description recalculations

Last year there was no recalculation.

4.9.4. Source-specific planned improvements

This category contains a number of unknown consumers of these fuels. In order to avoid double counting, further analysis is needed.

4.10. References

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5. SOLVENT AND OTHER PRODUCT USE (CRF Sector 3.)

5.1. Overview of the sector

5.1.1. Source category description

Emitted gases: N_2O, CO_2, NMVOC
Key sources: Level and Trend, Other (3.D), N_2O

5.1.2. Methodological issues

Primarily, emissions from paint and solvent uses were calculated in this sector. In addition, technologies related to use of N_2O are included. The figure below shows the time series of the emissions from the sector:

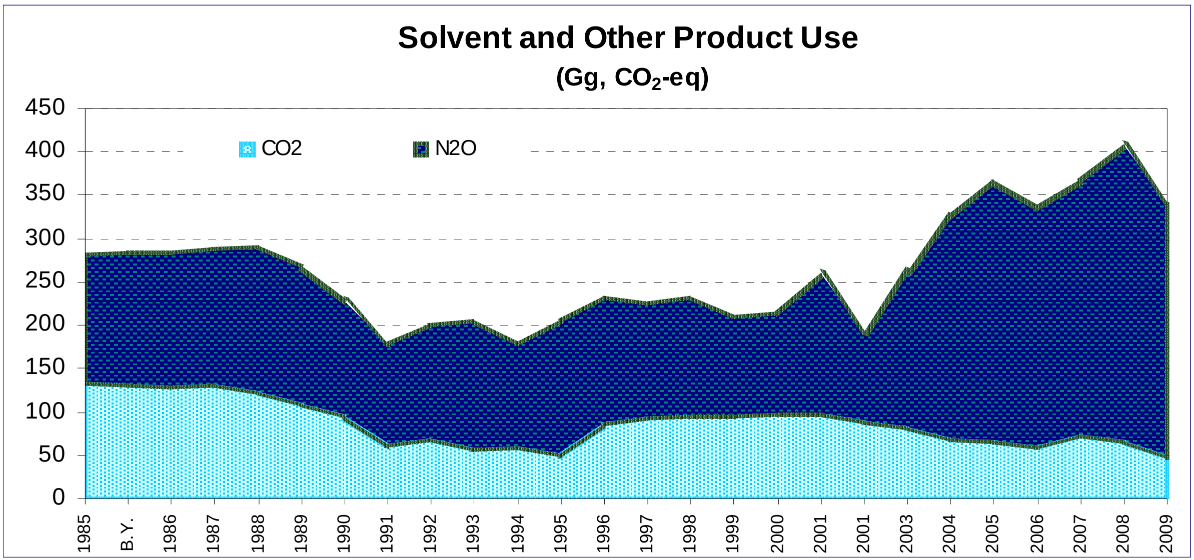
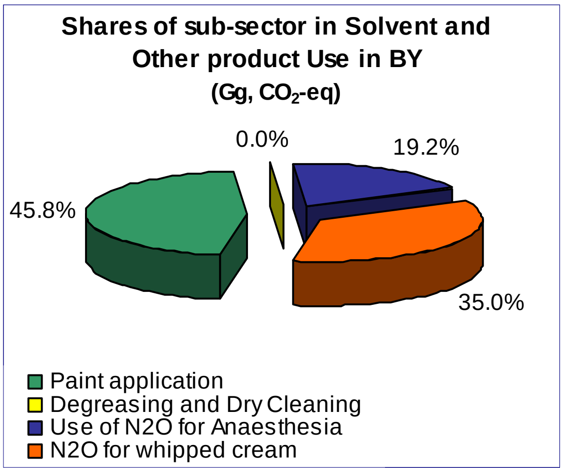


***Figure 5.1**. CO_2 and N_2O emissions in Solvent and Other Product Use sector (1985-2009)*

In 2009 this category had a contribution of 0.5% (excluding LULUCF) to total greenhouse gas emissions (340.09 Gg CO_2 equivalents). There has been an increase of 19.5% from base year to 2009 and drop of 16.3% between 2008 and 2009.



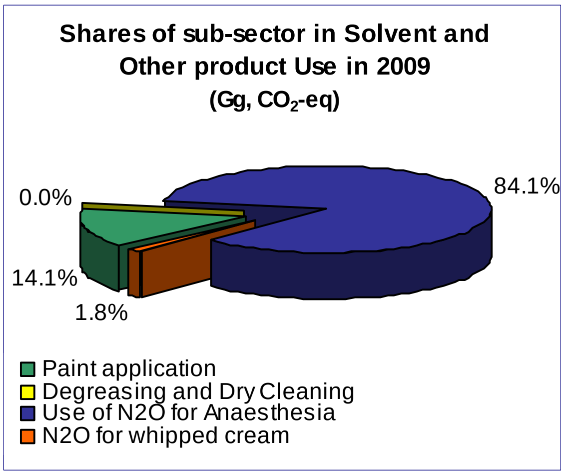


***Figure 5.2**. Shares of sub-sectors in Solvent sector, in base year and 2009 (Gg CO_2-eq)*

In the base year, the paint application sub-sector accounted for 45.8% of total GHG emissions from solvents, followed by emission from whipped cream sub-sector 35.0%, use of N_2O for anaesthesia sub-sector 19.2% and degreasing and dry cleaning 0.04%. In 2009, use of N_2O for anaesthesia sub-sector accounted for 84.1%, followed by paint application 14.1%. Less than 2% arose from whipped cream sub-sector and only a slight amount from degreasing and dry cleaning sub-sector (*Figure 5.2*).

5.2. Solvent Use (CRF Sector 3.A, 3.B)

5.2.1. Source category description

Paints and similar materials (lacquers, kits, glues) used in various sectors and households etc. contain diverse amounts of organic solvents. During use, they are applied to a surface and the solvents evaporate. The amount of the resulting NMVOC and that of the CO_2 released there are calculated.

5.2.2. Methodological issues

Data on paint and solvent uses were obtained from the data supplies of the Hungarian Central Statistical Office (KSH) or from Statistical Yearbooks. In 1996, KSH altered the type of data collection, and this is the cause of increase in that year in the diagram above. Compositions and solvent contents were discussed with the Paint Industry. Paints, lacquers, kits etc. were classified into several groups according to the average solvent content. The Revised Guidelines provide little help for calculation of specific values. NMVOC emissions were taken to be equal to the amount with solvent. You can find detailed description in ANNEX 3.
Specific emission factors show in the next table (t emission/t paint):

Table 5.1. *NMVOC and CO_2 emission factors in Paint Application sub-sector*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
IEF NMVOC, t/t	0.318	0.267	0.278	0.290	0.255	0.241	0.224	0.381	0.361	0.283
IEF CO_2 t/t	0.932	0.779	0.810	0.845	0.737	0.693	0.641	1.115	1.051	0.806
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
IEF NMVOC, t/t	0.263	0.252	0.224	0.204	0.184	0.219	0.226	0.236	0.204	0.195
IEF CO_2 t/t	0.744	0.709	0.624	0.564	0.502	0.616	0.637	0.668	0.568	0.542

The decreasing trend reflects the increasing proportion of water based paints. The emissions of chlorinated hydrocarbons used for degreasing and dry cleaning were determined by expert estimation to be 10 %. Emissions were taken into consideration on the basis of reports from the industry and the amounts were calculated using the above ratio.

5.2.3. Uncertainties and time series consistency

The uncertainty associated with the amount of materials used is considered moderate. Primarily, this results from the fact that the calculations were based on national sales data not reflecting commercial stocks and the subsequent sales there from, instead of amounts actually used. However, the error created by this is balanced when averaged for several years. The error of this calculation is due to the lack of information on the exact solvent content and solvent composition of the materials used, and thus, to being limited to average values. As a result of the above, the uncertainty of the emission calculations is estimated to be medium. The time series consistency may be considered limited because KSH altered the method of data collection in 1996, and the breakdown of published data on uses differs from that applied before 1996.

5.2.4. Source-specific QA/QC information and verification

No sector specific information is available.

5.2.5. Source-specific *recalculations*

Last year there was no recalculation.

5.2.6. Source-specific planned improvements

None.

5.3. Use of N_2O (CRF sector 3.D)

5.3.1. Source category description

This sub-sector includes less detailed technologies involving N_2O uses. One of the technologies considered is the use as an anaesthetic gas. Another, which was explored, is household whipped cream preparation. In Hungary, making whipped cream in siphons using N_2O cartridges is highly popular (although decreasing).

5.3.2. Methodological issues

Data on uses were obtained from the manufacturers. A significant proportion of cartridges manufactured for whipped cream is exported, thus, only domestic uses were considered.
N_2O production and domestic uses (tons):

Table 5.2. *N_2O emission (1985-2009, t)*

N_2O (t)	*Base year*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Anaesthesia	176.04	215.35	214.26	261.37	308.84	252.00	353.98	333.03	298.95	328.16
Cartridge	321.29	206.65	162.74	164.63	167.16	137.00	145.02	136.97	131.05	112.84
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Anaesthesia	304.45	459.31	275.22	533.02	789.69	931.90	864.45	926.77	1076.66	923.18
Cartridge	70.55	60.69	55.78	44.98	37.81	38.60	29.59	23.48	23.10	19.35

The cartridge refilling loss is high (approx. 30 %) and this is taken into account in the calculations. According to manufacturer information, N_2O is released from the body in an unaltered form; therefore, the emission factor is set to 1.

5.3.3. Uncertainties and time series consistency

Production data are highly reliable because they are obtained directly from manufacturers. Provided that the information on the unaltered form is correct, the emitted amounts are also highly reliable. The time series data are also considered highly reliable and consistent.

5.3.4. Source-specific QA/QC information and verification

No sector specific information is available.

5.3.5. Source-specific recalculation

Last year there was no recalculation.

5.3.6. Source-specific planned improvements

None.

6. AGRICULTURE (CRF sector 4.)

6.1. Overview of sector

Agriculture production contributed to the greenhouse gas emission at national level through the following processes:

- 4A Enteric Fermentation by domestic livestock (CH_4),
- 4B Manure Management (CH_4 and N_2O)
- 4C Rice cultivation (CH_4),
- 4D Agricultural soils (N_2O)
- 4F Field Burning of Agricultural Residues (it has not been occurring since 1990 and therefore not reported for 1991-2008)

Category 4C Burning of Savannas is not occurring and therefore not reported in Hungary.

Main greenhouse gas emissions from Agriculture are CH_4 and N_2O. There are no CO_2 emissions reported in the Agriculture sector. CO_2 emissions from agricultural soils are reported in the LULUCF Sector. CO_2 emissions from energy consumption of agricultural activities (heat production, agricultural vehicles and machinery) are reported in the Energy sector (1.AA.4C Energy, Other Sectors, Agriculture/Forestry/Fishing).

As an outcome of the 2010 in-country review of Hungary's national GHG inventory, the ERT recommended to improve the documentation (choice of methods, parameters used, rationale behind and recalculations) in the NIR. Therefore the NIR has been supplemented with the information required for the current submission.

To give an overview of Hungarian agriculture the main characteristics are as follows:
Due to national conditions agriculture played a definitive role in the Hungarian economy in the past and even today. The share of agriculture in the GDP was 2.5 percent in 2009 (HCSO, 2010a). The agricultural land area was 62 percent of the total (HCSO, 2010b). According to the provisional data of the General Agricultural Census, 2010 (HCSO, 2010c), 8800 economic enterprises and 567 thousands private farms had been operated in Hungary. The farm structure of agricultural enterprises and private farms is rather different. The agricultural enterprises managed dominantly 300 ha, whereas three quarter of the private farms managed one ha or less than one ha.
Currently 2080 agricultural enterprises and 285 thousand private farms deal with animal husbandry. Although the number of private farms is more significant, the bulk of the GHG dominant livestock populations are owned by agricultural enterprises. Two third of the cattle population and three quarter of the swine population are in agricultural enterprises. The private farms are only determining in sheep farming, 85 percent of sheep population is owned by them. The agricultural enterprises and private farms play approximately an equivalent role relating to poultry farming.

The main characteristics for trends are as follows:
In Hungary, agricultural production practically stopped growing in the late 1980's. This was followed by a dramatic drop in the 1990s, as a result of the economic and political transition taking place in the country. The gross value of agricultural production dropped, by 20 to 40 percent from the level of the 1980s. The drop was smaller for crop production (10-30%) than for animal husbandry. The output of the latter was only two third or less of the level of 1990 (Laczka and Soós, 2003). The volume index of gross agricultural production reached a minimum in 1993 of 69.1 percent of the level of 1990. The crop production has fluctuated considerably since 1993. It dropped in 2002-2003 and 2007 due to drought. In contrast, the

agricultural production was relatively high due to the significantly high crop production in 2004 and 2008. The animal husbandry remained at a low level between 1993 and 2004, and has been decreasing steadily since the year of the European Union accession (2004) (Laczka, 2007).

6.1.1. Emission trends

In 2009, the agriculture sector contributed 12.5% of Hungary's total GHG emissions (excluding LULUCF).

The trend of emissions shows a decrease of 52.7% over the period of 1985-2009 as a result of decrease in activity data. The contribution of agriculture to total emissions decreased from 15.4% to its present share of 12.5% in the years 1985-2009 (see Figure 6.1). The bulk of this decrease occurred between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. Between 1996 and 2008, agricultural emissions stagnated around 9.1 Mt with fluctuations up to 5%, and decreased by 9.5 percent in 2009 from the average of the years 1996-2008.

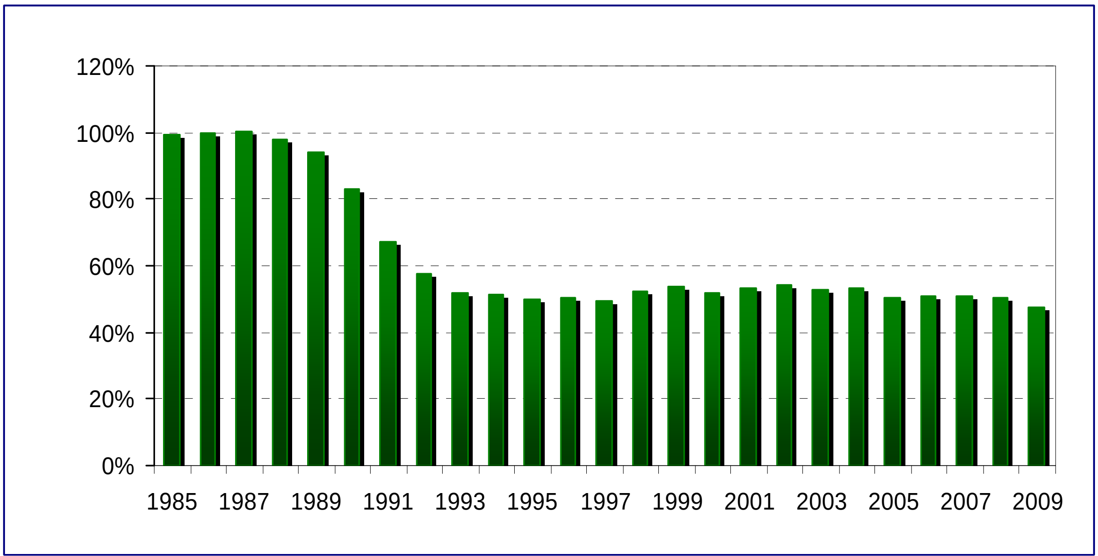


Figure 6.1. *GHG emissions from Agriculture in % of base years*

Emission trends per gas

From 1985 to 2009 CH_4 emissions from agriculture decreased by 56.7%, N_2O emissions decreased by 50.6%. The trends are presented in Table 6.1, Figure 6.2 and Figure 6.3

Table 6.1. *Emissions of CH_4 and N_2O from Agriculture 1985-2009*

Year	GHG emissions [Gg]	
	CH_4	N_2O
BY	283.75	37.39
1985	289.32	36.69
1986	283.15	37.44
1987	278.78	38.04
1988	276.98	36.54
1989	266.46	35.30
1990	270.65	28.62
1991	243.38	21.46

Year	GHG emissions [Gg]	
	CH_4	N_2O
1992	206.24	18.71
1993	181.29	17.00
1994	159.44	18.18
1995	160.44	17.28
1996	163.69	17.48
1997	155.17	17.43
1998	160.63	18.87
1999	162.78	19.30
2000	158.31	18.71
2001	152.16	19.87
2002	153.75	20.23
2003	152.64	19.56
2004	142.72	20.59
2005	137.37	19.25
2006	133.76	19.65
2007	134.57	19.76
2008	129.20	19.73
2009	122.90	18.48
Share in Hungarian total in BY	48.2%	69.0%
Share in Hungarian total in 2009	30.7%	84.4%
Trend BY-2009 (%)	-56.7	-50.6

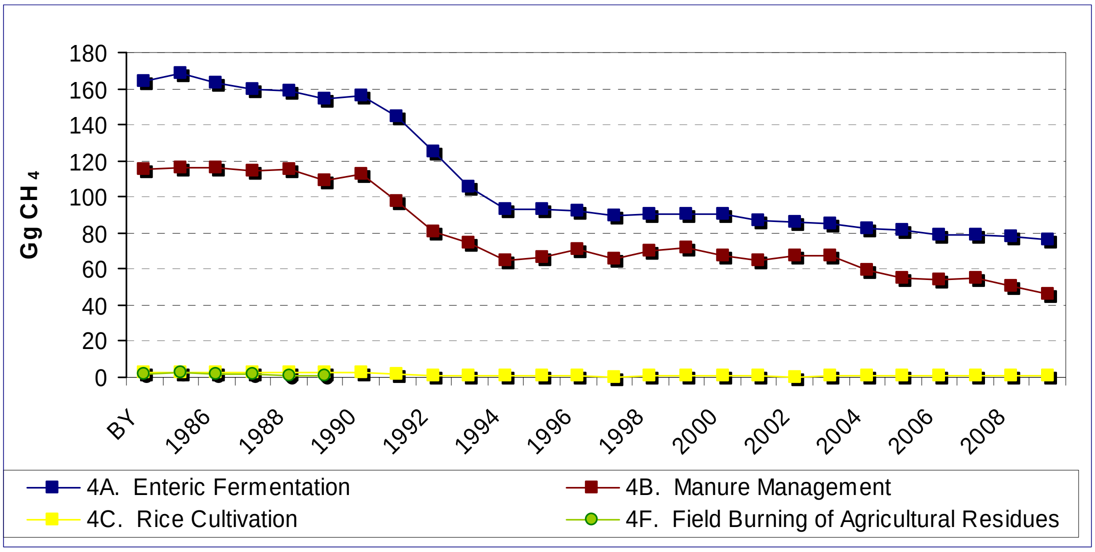


***Figure 6.2.** CH_4 emissions from Agriculture*

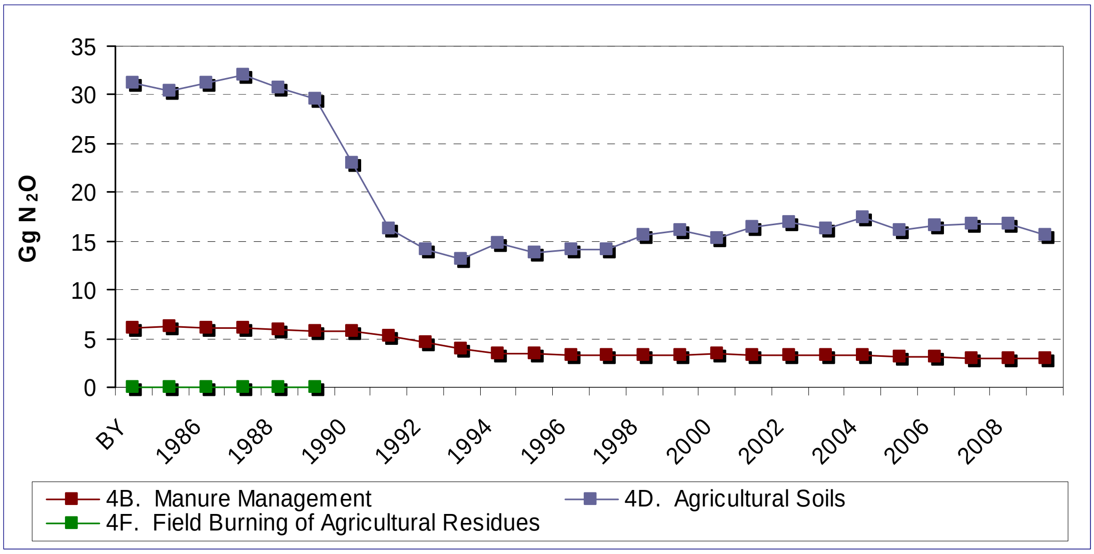


Figure 6.3. *N_2O emissions from Agriculture*

Emission trends per subcategory

Table 6.2 and Figure 6.4 show the trends in GHG emissions by subcategory as well as their contribution to the overall national emissions. The most important category is 4.D Agricultural soils at 7.2%, followed by 4.B Manure management at 2.8%, and 4.A Enteric fermentation at 2.4%. 4.C Rice cultivation accounts for the remaining less then one-tenth of a percent.

GHG emissions amounted to 17,549.5 Gg CO_2-eq in the BY and 8,309.7 Gg CO_2-eq in 2009, which means a reduction of 52.7%. The total emission from the Agriculture sector in 2009 was the lowest over the whole time-series.

Emissions decreased significantly in the period 1991-1995 reflecting the dropping agricultural production as a result of the economic and political changes in 1990. (See Chapter 6.1) In the period 1996-2008, emissions stayed at that low level, fluctuating around approximately 9.1 million tonnes (52% of the BY). Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of nitrogen fertilizer increased by 67.5% until 2007, which caused growing nitrous-oxide emissions from agricultural soils.

In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels. Although fertilizer prices decreased during 2009, they stayed relatively high, especially at the beginning of the year, which led to lower synthetic fertilizer use, again. Besides, the lower harvested production resulted in lower emissions from crop residues in agricultural soils in 2009 compared to its high level in 2008. The overall impact of the high fertilizer prices was a 14 percent decrease in nitrogen fertilizer use from the level of 2007, which contributed to the 7.1 percent decrease in the emissions from agricultural soils between 2007 and 2009.

The continued decline in livestock resulted in further decrease in emissions from the Agriculture sector in 2009. Mainly the decrease in swine population caused reduction of methane emissions here. Although the forage prices were more favorable than in 2008, the falling profitability of swine farming in private farms resulted in an 11 percent reduction of swine population. As a result, emissions decreased by 9.5% in 2009 compared to the average of the period 1996-2008.

Table 6.2. GHG emissions 1985-2009 from agriculture by subcategories

Year	GHG emissions [Gg CO_2-eq]					
	4 Agriculture Total	4.A Enteric Fermentation	4.B Manure Management	4.C Rice Cultivation	4.D Agricultural Soils	4.F Field Burning
BY	17,550	3,436	4,327	51	9,678	59
1985	17,449	3,532	4,369	47	9,425	75
1986	17,552	3,420	4,326	49	9,700	56
1987	17,647	3,355	4,285	55	9,908	45
1988	17,144	3,326	4,231	55	9,503	29
1989	16,539	3,235	4,061	50	9,178	15
1990	14,555	3,270	4,123	50	7,112	NO
1991	11,765	3,026	3,683	38	5,019	NO
1992	10,132	2,618	3,124	21	4,370	NO
1993	9,077	2,217	2,782	21	4,057	NO
1994	8,984	1,964	2,440	21	4,560	NO
1995	8,725	1,954	2,465	17	4,290	NO
1996	8,856	1,933	2,508	13	4,402	NO
1997	8,663	1,879	2,381	9	4,393	NO
1998	9,223	1,901	2,492	10	4,821	NO
1999	9,401	1,905	2,516	9	4,971	NO
2000	9,124	1,898	2,471	14	4,742	NO
2001	9,355	1,828	2,402	10	5,115	NO
2002	9,499	1,804	2,442	9	5,245	NO
2003	9,268	1,784	2,452	11	5,021	NO
2004	9,380	1,729	2,261	12	5,378	NO
2005	8,853	1,718	2,137	11	4,988	NO
2006	8,899	1,665	2,083	10	5,141	NO
2007	8,953	1,664	2,087	11	5,191	NO
2008	8,830	1,637	1,989	11	5,193	NO
2009	8,310	1,609	1,869	11	4,821	NO
Share in Hungarian total in BY	15.4%	3.0%	3.8%	0.04%	8.5%	0.1%
Share in Hungarian total in 2009	12.5%	2.4%	2.8%	0.02%	7.2%	0.0%
Trend BY-2009	-52.7%	-53.2%	-56.8%	-77.5%	-50.2%	100%

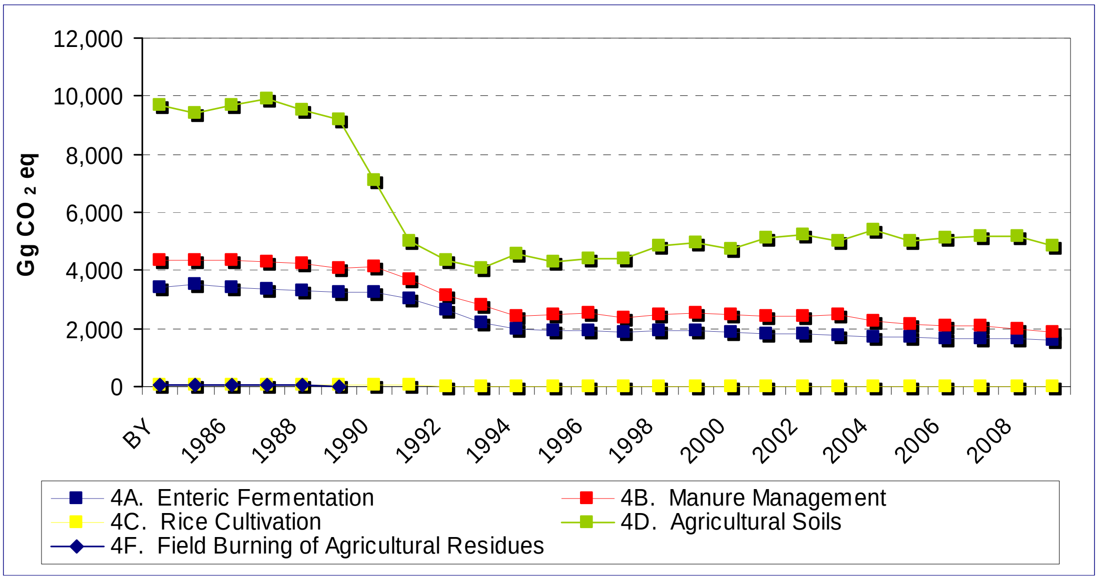


Figure 6.4. *GHG emissions from Agriculture*

6.1.2. Key Categories

Key category analysis is presented in Chapter 1.6, Table 1.1 and Table 1.2 contains the key categories of the agriculture sector.

6.1.3. Methodological issues

Mainly the methods recommended by the Good Practice Guidance (IPCC, 2000) were applied. In some cases where the GPG (IPCC, 2000) refers to the emission factors and parameters published in the Revised Guidelines (IPCC, 1996), the latter one was used. In cases where parameters were not provided in the guidelines mentioned above, the 2006 IPCC Guidelines was applied.

In accordance with the recommendation of the Centralized Review 2008, IPCC Tier 2 method was applied in the following categories: 4A Enteric Fermentation Dairy Cattle, 4A Enteric Fermentation Non-Dairy Cattle, 4B Manure Management (CH_4) by all livestock categories, except Rabbits. In other categories IPCC Tier 1 method was applied. Country-specific factors were used whenever sufficient information was available, otherwise the IPCC default factors were applied. See the individual categories for further details.

6.1.4. Uncertainties and time-series consistency

The following chapter gives an overview of uncertainty estimates for CH_4 and N_2O emissions from Agriculture.

As a result of our QC activity, the uncertainty estimates relating to the Agriculture sector has been recalculated in 2010. The revision of the uncertainty assessment mainly concentrated on the correction of the calculation errors and the collection of available uncertainty ranges of the activity data and the emission factors. The previously used T1 method suggested by the GPG (IPCC, 2000) has been applied henceforward, but the uncertainties were estimated as upper (97.5 percentile) and lower (2.5 percentile) ranges of a 95% confidence interval in this submission. Error propagation has been calculated independently for the lower and for the upper range to treat the asymmetric confidence ranges. In Table 6.4 the arithmetic mean of the upper and lower uncertainties are reported.

The uncertainty of the activity data was calculated on the basis of the available data of the HCSO, the CORINAIR Guidebook (EEA, 2007) and expert judgement; the uncertainty of the emission factors was calculated on the basis of the GPG (IPCC, 2000) recommendations. Uncertainties were combined in accordance with GPG (IPCC, 2000) Equation 6.3 and Equation 6.4, and Table 6.1 contains the results.

In the Hungarian agricultural GHG inventory, the uncertainties of the Direct Soil Emissions and the Indirect Soil Emissions categories are the highest. These high values derive from the uncertainty of the activity data (to a smaller extent) and of the emission factors (to a greater extent). In accordance with the recommendation of the Guideline (IPCC, 2006) the uncertainty of the Direct and Indirect emissions from agricultural soils are reported and treated separately, because of their correlation.
The uncertainty of the livestock population data are presented in Table 6.3. The overall uncertainties of the activity data, emission factors and emissions by subcategories are summarized in Table 6.4. For more details of the uncertainty assessment see the subsector chapters. The reported uncertainty of the CH_4 emissions from Enteric Fermentation and Manure Management is lower than what was reported for 2008, because of the lower uncertainty of the Tier 2 emission factors. In contrast, the uncertainty of the N_2O emissions from Agricultural soils is higher now than in the previous submission. In this submission the IPCC default uncertainty of EF_1 (-80%/+380%) was applied instead of the estimated ±250% used formerly. The uncertainty of the N_2O emissions from 4.D.2 has a significant influence on the overall uncertainty, therefore the revision of the uncertainty of EF_1 emission factor resulted a significant change in the overall uncertainty of the Hungarian GHG inventory as well.

Table 6.3. *Uncertainty of animal population data (HCSO)*

Livestock categories	2008 Dec	2009 Jun	2009 Dec	Annual mean	Uncertainty of the annual mean $u(AD_i)$	Weighted annual mean
	95% Confidence Interval [+/- 1,000 head]				%	1,000 head
Dairy Cattle	9.20	9.40	9.10	5.71	2.22	257.50
Non-Dairy Cattle	9.90	10.60	11.70	6.54	1.47	444.25
Buffalo	0.10	0.10	0.20	0.08	5.08	1.48
Sheep	144.00	160.00	147.90	95.20	7.55	1260.75
Goats	8.20	8.20	5.90	4.82	7.41	65.00
Horses	4.70	4.70	5.20	2.93	4.91	59.75
Mules and Asses	0.90	0.70	1.10	0.50	25.95	1.93
Swine	56.10	53.10	48.50	32.38	1.00	3248.00
Poultry	2,384.01	4,895.29	2,906.00	2621.83	5.85	44789.25
Rabbit	50.80	63.50	45.30	36.02	4.13	871.25
Overall (weighted mean)					5.50	

Table 6.4. *Uncertainties of Activity Data, Emission Factors and Emissions*

4 Agriculture	GHG	Combined uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%	%	%
4.A Enteric Fermentation	CH_4	5.5	±20 – ±50	13
4.B Manure Management	CH_4	5.5	±30 – ±50	24
4.B Manure Management	N_2O	61.6	-50/+100	79
4.C Rice Cultivation	CH_4	5	-100/+189	149
4.D.1 Direct Soil Emissions	N_2O	31.6	-80/+380	234

4 Agriculture	GHG	Combined uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%	%	%
4.D.2 Pasture, Range and Paddock Manure	N_2O	42.5	-50/+100	87
4.D.3 Indirect Emissions	N_2O	-64/+156	±50	110

Note: Uncertainty of the emission factors for 4A Enteric Fermentation and 4B Manure Management CH_4 depends on animal species. For more details see sub-sector chapters.

6.1.5. Quality Assurance and Quality Control

The agricultural greenhouse gas inventory is compiled by the HMS in collaboration with the Research Institute for Animal Breeding and Nutrition. The used activity data are derived from the official database of the HCSO. The documentation of the QA/QC methods used by the HCSO can be found in the referred databases (HCSO 1985-1989 and 1997-2005; 1990-1996; 2000a; 2000b; 2001; 2004; ; 2010a; 2010b; 2010c). Calculation files contain checking data series. Data identity between data sources, calculation files and the CRF tables are controlled by a member of the GHG division.

The documentation is archived by the Hungarian Meteorological Service Greenhouse Gas Division and the Institute for Animal Breeding and Nutrition independently from each other. External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

In 2010 an overall QC procedure has been undertaken relating to the Agriculture sector.

In the course of this review, the following procedures were carried out.

Activity data:

- Comparison with the data sources, check for transcription errors.
- Check of the reasons of data gaps and stopping of them.
- Check of the parameters not listed in the GPG (IPCC, 2000) and comparison with the values reported by the other countries.
- Cross-checks across the subsectors.

Emission factors:

- Check of the country-specific emission factors, comparison with the default ones, and the reasons of the differences between the default and the country specific emission factors.
- Comparison of the country-specific emission factors with the values reported by other countries (UNFCCC, S&A Reports)

Method applied:

- Comparison of the applied methodology with the GPG (IPCC, 2000).

Reported emissions

- Comparison of the calculation sheet and the CRF tables for transcription errors.

All findings were summarized in a special QC report (Agricultural CH_4 and N_2O emissions in Hungary QC report).

6.1.6. Recalculations

The principal changes that resulted in recalculated estimations in 4.B Agriculture sector are as follows:

4.B Manure Management, CH_4

- Revision of CH_4 emission factors for poultry due to the modification of VS based on the Guidelines (IPCC, 2006) for all years 1985-2008.

4.B Manure Management, N_2O

- Minor revision of N excretion rate for dairy cattle for 2006-2008

4.D.1 Agricultural Soils, Direct N_2O-Emissions

- Minor revision of activity data in 4.D.1.2 Animal Manure Applied to Soils due to change in N excretion rate for dairy cattle for 2006-2008
- Minor revision of activity data in 4.D.1.3 N-fixing crops to fill data gaps in the datasets of harvested production for lucerna seed for 1996-2006 and for lentil, lupin and broad bean for 2006-2008.
- Minor revision of activity data in 4.D.1.4 Crop Residues due to filldata gaps in the datasets of harvested production for meslin for 2006-2008.
- Revision of crop residue statistics in 4.D1.3 N-fixing crops for 1985-2008.
- Revision of Residue to Crop Product Ratio for rice in 4.D1.4 for 1985-2008.

4.D.2 Agricultural Soils, Direct N_2O-Emissions, Pasture, Range and Paddock Manure

- Minor revision of activity data due to change in N excretion rate for dairy cattle for 2006-2008

4.D.3. Agricultural Soils, Indirect N_2O-Emissions, Atmospheric Deposition, 1985-2007

- Minor revision of activity data in 4.D.3.1 Atmospheric Deposition and in 4.D.3.2 Nitrogen Leaching and Run-off due to change in N excretion rate for dairy cattle for 2006-2008

The net effects of the recalculations are shown in Table 10.2.

6.1.7. Planned improvements

A multistage, methodological development program, jointly with the Research Institute for Animal Breeding and Nutrition, titled "Development and regular review of country specific emission factors for the agricultural greenhouse gas (methane, nitrous oxide) inventory" is in progress. In accordance with the recommendation of the Centralized Review currently the following problems are to be solved:

- 4A Enteric Fermentation: Revision of the calculation method of the country-specific emission factors for Dairy Cattle and Non-Dairy Cattle.
- 4B Manure Management, CH_4: Revision of the country-specific emission factors for Dairy Cattle, Non-Dairy Cattle and Poultry
- 4B Manure Management, N_2O: Revision of the country-specific Nitrogen-excretion rates.
- 4D Agricultural Soils, Crop residues: Development of country specific parameters of residue to crop product mass ratios and nitrogen fractions for sunflower and rape.

6.2. Enteric fermentation (CRF sector 4.A.)

6.2.1. Source Category Description

Emitted gas: CH_4
Key source: Level 1, 2; Trend 1;

Enteric fermentation in animals is considered as significant source of CH_4 all over the world. The most important process of generation is anaerobic cellulose degradation in the rumen of ruminants. Some CH_4 is generated in the colon of horses and rabbits, and in the caecum of poultry. In Hungary the leading CH_4 emitters are cattle and sheep, with the most important category being dairy cattle. In addition to the number of animals, the level of production and feeding practices are the factors primarily influencing the amount of CH_4 from enteric fermentation. In 2009 62.3% of the entire CH_4 emissions from agriculture derived from this source category.

6.2.2. Methodological issues

6.2.2.1 Calculation method

Emissions from enteric fermentation of livestock were calculated by using the Tier 1 method of GPG (IPCC, 2000), except for the Dairy Cattle and the Non-Dairy Cattle categories, where country specific emission factors were used in accordance with the Tier 2 method of GPG (IPCC, 2000).

6.2.2.2 Livestock Population

The time-series of annual livestock populations (Table 6.5) derives from the HCSO official statistics. The HCSO has been collecting data on livestock population twice a year, namely in June and in December since 1 January 2009. . The annual average population for 2009 were calculated by using the following equation:

$$NoA_{2009} = (0.5*NoA_{Dec2008}+NoA_{June2009}+0.5*NoA_{Dec2009})/2 \quad \text{(Equation 6.1.)}$$

Where:

NoA_{2009} = average annual population in the given livestock category in 2009. [1'000 head]
$NoA_{Dec2008}$ = population in the given livestock category in December 2008. [1'000 head]
$NoA_{June2009}$ = population in the given livestock category in June 2009. [1'000 head]
$NoA_{Dec2009}$ = population in the given livestock category in December 2009. [1'000 head]

It has to be noted that, until the end of 2008 the HCSO collected data on animal livestock population three times a year, (April, August and December). The calculation of the average annual population was similar to that is delineated above, but four data collection periods were used for averaging.

Table 6.5. *Livestock population 1985-2009*

Year	Animal Population [1,000 head]									
	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
1985	598	1,298	0.1	2,588	18	103	5.0	8,931	82,030	2,238
BY	585	1,228	0.1	2,498	19	99	5.0	8,920	82,816	2,319
1986	579	1,226	0.1	2,454	18	100	5.1	8,955	83,502	2,319
1987	579	1,160	0.1	2,453	22	93	5.0	8,876	82,914	2,400
1988	573	1,155	0.1	2,327	26	80	4.8	8,902	79,079	2,481
1989	569	1,109	0.1	2,172	31	79	4.6	8,457	74,591	2,562
1990	560	1,053	0.1	1,958	35	80	4.5	8,751	69,846	2,644
1991	518	1,007	0.1	2,009	39	84	4.3	7,558	57,540	2,978
1992	472	809	0.1	1,867	50	79	4.3	6,159	52,746	2,755
1993	438	627	0.1	1,458	61	75	4.3	5,760	44,013	2,096
1994	403	549	0.1	1,089	71	85	4.3	4,926	46,264	1,271
1995	392	553	0.2	998	76	75	4.3	5,089	45,092	1,378
1996	396	535	0.3	930	81	74	4.3	5,536	38,873	1,041
1997	387	512	0.4	901	86	76	4.3	4,953	45,874	933
1998	381	494	0.5	954	90	77	4.3	5,338	46,620	1,005
1999	385	484	0.6	981	95	78	4.3	5,585	40,722	912
2000	390	443	0.7	1,225	97	78	3.4	5,063	49,515	919

Year	Animal Population [1,000 head]									
	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
2001	377	416	0.8	1,164	108	65	3.6	4,821	52,116	1,138
2002	345	431	0.9	1,133	96	64	3.4	5,093	50,939	1,157
2003	330	428	1.0	1,259	94	62	3.3	5,049	53,550	1,148
2004	309	424	1.1	1,380	85	65	3.1	4,385	50,492	999
2005	300	420	1.2	1,447	78	67	2.6	4,022	46,405	1,003
2006	275	428	1.3	1,358	81	65	2.3	3,944	44,653	1,084
2007	267	443	1.4	1,301	72	59	2.1	4,037	43,162	1,055
2008	264	436	1.4	1,270	73	58	2.0	3,663	45,035	904
2009	258	444	1.5	1,261	65	60	1.9	3,248	44,789	871

Source: HCSO 1985-2010

6.2.2.3 Emission Factors

Emissions of CH_4 from enteric fermentation in Dairy Cattle and Non-Dairy Cattle categories were calculated using the Tier 2 method (GPG, Equation 4.14):

$$EF = (GE * Y_m * 365) / 55.65$$

(Equation 6.2)

Where:

EF	CH_4 emission factor [kg head^{-1} yr^{-1}]
GE	gross energy intake [MJ head^{-1} day^{-1}]
Y_m	methane conversion rate [MJ MJ^{-1}]
365	days of year [day yr^{-1}]
55.65	energy content of methane [MJ kg^{-1}]

<u>**Gross energy intake (GE)**</u> – Gross energy intakes for cattles and non-dairy cattles were determined as follows. The average body mass of dairy-cattles was determined for each year of the time-series by expert judgement (Várhegyi 2007, Györkös 2010, Bölcskey 2010). In Hungary the Dairy Cattle population consisted mainly of Holstein-Friesian and Holstein-Friesian Cross-bred in 1985 and still does. Therefore we estimated the average mass as 600 kg that was characteristic of the breed in 1985. The selection of this breed for milk yield resulted in growth of body size and body mass. For 2005 the average body mass was estimated as 650 kg. The average body mass was interpolated for the years in between. No growth in body mass was calculated for the period of 2006-2009.
The daily average milk yield (18.74 kg day^{-1} in 2009) was calculated based on the HCSO's annual milk yield statistics (see Table 6.6).
A characteristic total mixed ration (TMR) was calculated for each year of the time-series using the WINLP (nutrition software for dairy cow, Várhegyiné et al., 2007) according to the requirements of a dairy cow having the estimated annual average body mass and the daily average milk yield. The GE-content of the composed feed ration was applied for the estimation of the annual value of the emission factor.
To estimate the GE-intake for Non-Dairy Cattle a detailed livestock population's statistics (HCSO, 1985-2009) reflecting the age structure and animal performance was used. As a first step the average body mass for the livestock sub-categories were determined by expert judgment (Bölcskey, 2010). The average body mass for the Non-Dairy Cattle was calculated as the weighted average of the estimated mass of the different sub-categories for each year. The applied livestock sub-categories and their typical body mass are listed below:

Cattle less than one year old

Calves for slaughter, male (250 kg)
Calves for slaughter, female (240 kg)

Other calves, male (290 kg)
Other calves, female (270 kg)
Cattle aged between one and two
Male (550 kg)
Female for slaughter (heifers) (510 kg)
Female, other (500 kg)
Cattle of two years and over
Male (650 kg)
Female for slaughter (heifers) (550 kg)
Other, heifers (550 kg)
Cows, beef (650 kg)

The average body mass of the category varied between 366 kg and 434 kg in the period of 1985-2009. (431 kg in 2009)
In the second step the dry matter intake was calculated from the average body mass using the Equation 6.3. This regression equation was determined in accordance with the Hungarian Nutrition Codex, 2004.

$$y=0.0131x+2.2821,\ R^2=0.09988 \qquad \text{Equation 6.3}$$

where,
y= Dry matter intake (kg day-1)
x= Average body mass (kg)
R^2= Determination coefficient

The daily dry matter intake multiplied by the energy content of feed (18.45 MJ/kg DM) gives the daily average GE-intake.

Methane conversion rate (Y_m) – In the case of Dairy Cattle the methane conversion rate is assumed to be lower than the default value given in Table 4.8 of GPG (IPCC, 2000). For 2009 0.0577 [MJ MJ^{-1}] was assumed, and for 1985-2008 the methane conversion rate was in the range 0.0578-0.0595, because of the high concentrate/forage ratio characteristic in Hungary. Table 4.8 of GPG (IPCC, 2000) provides Y_m value between 0.055 and 0.065 (0.060 ± 0.005), depending on the composition (concentrate / forage ratio), quality and digestibility of the feed ration. In Hungary the dairy cattle population generally receives good quality TMR feed, depending on the dairy production level, along with relatively high concentrate ratio.
The feed ration of a dairy cow having the average milk yield and average body mass was compiled for each year of the time-series. The concentrate/ forage ratios were also calculated for each year. The Y_m value was estimated on the basis of the concentrate %, which turned to be slightly below the IPCC default value for 1985 (concentrate % = 16.4, Y_m = 0.0595). As regards 2005, concentrate % increased to 25.9% and the Y_m value was estimated as 0.058. The Y_m value was interpolated for the years between 1985 and 2005, and extrapolation was carried out for 2006-2009.
In the case of Non-Dairy Cattle category the IPCC default value of 0.06 MJ MJ^{-1} was used in the Tier 2 calculations.

Table 6.6 and 6.7 summarizes the emission factors used for the calculations. In the case of Buffalo, Sheep, Goats, Horses, Asses & Mules, Swine, Poultry and Rabbits categories GPG Tier1 and IPCC default emission factors were used.

***Table 6.6.** Annual milk yield, gross energy intake, methane conversion rate and emission factors for Dairy Cattle and Non-Dairy Cattle 1985-2009*

Year	Dairy Cattle				Non-Dairy Cattle		
	Milk Yield	Gross Energy Intake	Methane Conversion Rate [Y_m]	CH_4-Emission Factor	Gross Energy Intake	Methane Conversion Rate [Y_m]	CH_4-Emission Factor
	[kg cow^{-1} yr^{-1}]	[MJ $head^{-1}$ yr^{-1}]	[MJ MJ^{-1}]	[kg $head^{-1}$ yr^{-1}]	[MJ $head^{-1}$ yr^{-1}]	[MJ MJ^{-1}]	[kg $head^{-1}$ yr^{-1}]
1985	4,518	272.58	0.0595	106.37	131.26	0.06	51.66
BY	4,708	278.32	0.0594	108.48	131.22	0.06	51.66
1986	4,757	279.69	0.0594	109.01	131.26	0.06	51.66
1987	4,849	282.70	0.0594	110.05	131.13	0.06	51.60
1988	4,996	287.30	0.0593	111.69	130.69	0.06	51.43
1989	5,015	288.18	0.0592	111.89	131.45	0.06	51.73
1990	5,068	290.22	0.0591	112.55	147.11	0.06	57.89
1991	4,789	282.80	0.0591	109.53	143.93	0.06	56.64
1992	4,865	285.47	0.0590	110.42	143.41	0.06	56.44
1993	4,738	282.30	0.0589	109.06	141.87	0.06	55.83
1994	4,786	284.18	0.0588	109.64	141.16	0.06	55.55
1995	5,025	291.19	0.0588	112.21	141.62	0.06	55.73
1996	4,977	290.44	0.0587	111.77	140.80	0.06	55.41
1997	5,120	294.75	0.0586	113.29	140.80	0.06	55.41
1998	5,507	306.01	0.0585	117.46	140.80	0.06	55.41
1999	5,453	304.87	0.0585	116.88	140.80	0.06	55.41
2000	5,479	306.10	0.0584	117.20	140.38	0.06	55.24
2001	5,665	311.64	0.0583	119.16	140.02	0.06	55.10
2002	6,161	325.94	0.0582	124.47	139.76	0.06	55.00
2003	6,154	326.10	0.0582	124.37	140.71	0.06	55.37
2004	6,131	326.04	0.0581	124.19	142.52	0.06	56.08
2005	6,429	334.59	0.0580	127.28	142.76	0.06	56.18
2006	6,682	341.86	0.0579	129.88	144.37	0.06	56.82
2007	6,874	347.30	0.0579	131.77	145.34	0.06	57.20
2008	6,971	350.19	0.0578	132.70	145.95	0.06	57.44
2009	6,841	346.98	0.0578	131.48	146.19	0.06	57.53

***Table 6.7.** The emission factors used for the calculation of the methane emissions from enteric fermentation*

Animal category	CH_4-emission factor [kg head^{-1} yr-^{1}]	Comments
Dairy Cattle	see Table 6.4	*country specific value, Tier 2*
Non-Dairy Cattle	see Table 6.4	*country specific value, Tier 2*
Buffalo	55	*IPCC default value for developed countries*
Sheep	8	*IPCC default value for developed countries*
Goats	5	*IPCC default value for developed countries*
Horses	18	*IPCC default value for developed countries*
Asses & Mules	10	*IPCC default value for developed countries*
Swine	1.5	*IPCC default value for developed countries*
Poultry	0.015	*expert judgement, according to Minonzio et al. (1998)*
Rabbits	0.08	*expert judgement, according to NIR of Italy, 2008*

6.2.3. Uncertainties and time-series consistency

Uncertainty of activity data (animal population) was estimated for each animal species for the data collection period by the HCSO. The uncertainty of the mean annual averages was estimated according to the error propagation rules. (See Table 6.3) For the uncertainty of the country specific EFs ±20% were assumed, while for the default EFs ±50% was applied in accordance with the GPG (IPCC, 2000). The combined uncertainty of the emissions from the 4.A sector is ±13 percent, which is lower than what was reported last year, due to the lower uncertainty of the country-specific emission factors.

6.2.4. QA/QC Information

See 6.1.5.

6.2.5. Source-specific recalculations

Recalculation was not required.

6.2.6. Planned improvements

Further development of the country-specific emission factors for Dairy Cattle and Non-Dairy Cattle.

6.3. Manure management (CRF sector 4. B.)

6.3.1. Source Category Description

Emitted gas: CH_4, N_2O
Key source: Level 1, 2; Trend 1, 2;

Animal manure is an important source of CH_4 and N_2O. The amount of CH_4 and N_2O emitted from the manure to the atmosphere depends on the conditions of manure management and use as well as on the composition of released excrements. In 2009 37% (CH_4) and 16% (N_2O) of the agricultural emissions arose from this source category

6.3.2. Methodological issues

6.3.2.1 Calculation method

CH_4 emissions from manure management (excluding Rabbits category) were estimated by using the Tier 2 methodology.
N_2O emissions from manure management were calculated by applying Tier 1 methods, although in the case of the annual N-excretion, country specific data were used for Dairy Cattle, Non-Dairy Cattle and Swine.

6.3.2.2 Activity data

Number of Livestock - See chapter 6.2.2 and Table 6.5 regarding livestock activity data.
Annual average Nitrogen excretion rates (N_{ex}) – country specific parameters were used for Dairy Cattle, Non-Dairy Cattle Swine, based on Fébel and Gundel (2007).
In the case of dairy cattle this study provides N-excretion rates per body mass for four milk yield categories. The annual N-excretion rates were calculated from the values of the provided N-excretion rates per body mass and daily milk yield category, multiplied by the body mass. The N-excretion rates per body mass given by the study were used to calculate the country-specific Nitrogen excretion rates for Non-Dairy cattle and Swine as well. In the case of the other livestock categories the default values provided by Table 4-20, on p. 4.99 in the Revised Guidelines, Ref. Man., Table 4-20, p. 4.99 were used. For horses and goats, which are not listed in the above table, values were taken from the literature (Walther et al., 1994) and in the case of rabbit, the value provided by the EMEP-Corinair Guidebook (EEA, 2002) was applied. The values of nitrogen excreted and their sources are showed in Table 6.8 and 6.9.
Typical Body Mass of Livestock Categories – see 6.2.2.3 for the estimation of the typical body mass of the Dairy Cattle and the Non-Dairy Cattle categories. As regards swine population the HCSO's detailed livestock data and the body mass of the subcategories based on expert judgment (Egerszegi, 2010) were used. The typical body mass of the swine population was determined annually as the weighted average of the body masses of the sub-categories as follows:

Piglets under 20 kg (average 11 kg)
Young pigs, 20-50 kg (average 35 kg)
Pigs for fattening over 50 kg
    Pigs for fattening over 50-79 kg (average 65 kg)
    Pigs for fattening over 80-109 kg (average 95 kg)
    Pigs for fattening 110 kg and over 110 kg (average 120 kg)
Breeding sows
    Breeding sows in farrowing (180 kg)
    Breeding sows, draft (180 kg)
Sows mated for the first time (180 kg)
Gilts not yet mated (76 kg)
Breeding boars (210 kg)

The average body mass of the category varied between 60 kg and 70 kg in the period of 1985-2009.

Manure Management System Distribution – As regards the analysis of the manure management systems the following should be noted:
The latest analysis on the distribution of the Hungarian manure management systems occurred in 2005. At that time the allocation of the nitrogen generated in different manure management systems were estimated on the basis of expert consultations (Mészáros 2000) and of the study ”Building capacity and capacity utilisation of animal production and the

technical conditions of the major farms" (Ráki 2003, in Hungarian). These estimations have been used since then.
Ráki (2003) processed three databases: the General Agricultural Census 2000 (HCSO), data from the legally required registration of agricultural producers in 2000 (this includes data for agricultural enterprises) and a registration of animal production holdings performed in October and November 2001, which covered the capacity, capacity exploitation and conditions of buildings and equipment. This survey allows conclusions to be drawn in connection with the entire animal management sector because it covers 70% to 100% of the livestock populations depending on the given category.
The concrete values used for emission calculations were determined on the basis of the ratios of places provided in the study (Ráki 2003) and of personal expert consultations (György Mészáros, Ministry for Agriculture and Rural Development, 2000, verbal communication). The following tables of the study served as the basis of the calculations:

Cattle: Appendix 53 - 55; Page 115 -117
Sheep: Appendix 75; Page 137
Poultry: Appendix 78 - 80; Page 139 – 40
Appendix 102 - 105; Page 152 – 153
Appendix 111 – 126; Page 156 – 162
Appendix 130 – 149; Page 165 – 172

For the remaining livestock categories the expert judgement of Mészáros (2000) was used.
The allocation of animal manure per AWMS systems data were updated by a new surway for sheeps and goats for 2009. To provide reliable data on the features of sheep production relating to GHG emissions, a survey using sampling approach were carried out by the Research Institute for Animal Breeding and Nutrition in 2010. The sampling was based on questionnaires and on-site surveys. The selected farms for this survey represented all kind of technology and size of farms characteristic in the sheep sector in Hungary. 75 farms were measured by questionnaires and 10 farms were examined on-site. This survey covers 95 thousands animal places. Besides the sheep farms also two goat farms were surveyed on-site. The survey results were published by Borka et al. in 2010.
In accordance with this study (with exception of grazing) only solid systems has been used in manure management for sheep and goat since 2009.

Table 6.8, 6.9, 6.10 and 6.11. summarise the data on the estimation of average annual nitrogen emissions of the individual livestock categories and of nitrogen excreted in the various manure management systems.

Table 6.8. *Annual average Nitrogen excretion rates (N_{ex}) for Dairy Cattle, Non-Dairy Cattle and Swine 1985-2009*

Year	Dairy Cattle	Non-Dairy Cattle	Swine
	[kg head^{-1} yr^{-1}]	[kg head^{-1} yr^{-1}]	[kg head^{-1} yr^{-1}]
1985	91.99	41.08	9.51
1986	93.76	41.08	9.44
1987	94.68	41.03	9.60
1988	95.93	40.78	8.67
1989	96.43	41.14	8.76
1990	97.14	48.59	8.41
1991	95.89	46.78	8.87
1992	96.73	46.46	8.30

Year	Dairy Cattle	Non-Dairy Cattle	Swine
	[kg head^{-1} yr^{-1}]	[kg head^{-1} yr^{-1}]	[kg head^{-1} yr^{-1}]
1993	96.37	45.76	8.63
1994	97.04	45.39	8.69
1995	98.87	45.63	8.71
1996	98.97	45.26	8.33
1997	100.23	45.26	7.95
1998	102.97	45.26	7.86
1999	103.06	45.26	8.09
2000	103.62	45.06	8.06
2001	105.17	44.91	7.99
2002	108.63	44.79	7.91
2003	109.01	45.37	8.19
2004	109.29	46.29	8.21
2005	111.57	46.48	8.13
2006	113.15	47.32	8.02
2007	114.34	47.79	8.03
2008	114.95	48.17	8.13
2009	114.14	48.27	8.07

Source: Expert judgements (Gundel 2004, Várhegyi 2004, Fébel 2007) and literature data (Várhegyiné et al. 1999, Babinszky et al. 2002, Fébel and Gundel 2007) it was assumed that production level and feeding technology of animal breeding in Hungary are close to the Western European standards, therefore the default IPCC factors for Western Europe were used.

Table 6.9. *Annual average Nitrogen excretion rates (N_{ex}) for Buffalo, Sheep, Goats, Horses, Asses and Mules and Poultry*

Animal Category	N_{ex} [kg head^{-1} year^{-1}]	Comments
Buffalo	70	IPCC, Western Europe
Sheep	20	IPCC, Western Europe
Goats	18	Walther et al. (1994)
Horses	60	Walther et al. (1994)
Asses & Mules	25	IPCC, Western Europe
Poultry	0.6	IPCC, Western Europe
Rabbits	4.1	EMEP-Corinair (2002)

Source: Revised Guidelines, Ref. Man., Table 4-20, p. 4.99, Walther et al. (1994), EMEP-Corinair (2002)
Notes: On the basis of expert consultations (Gundel 2004, Várhegyi 2004, Fébel 2007) and literature data (Várhegyiné et al. 1999, Babinszky et al. 2002, Fébel and Gundel 2007) it was asserted that production level and feeding technology of animal breeding in Hungary are close to the Western European standards, therefore the default IPCC factors for Western Europe were used.

Table 6.10. *Allocation of animal manure per AWMS, volatile solid excretion rate, maximum methane producing capacity and CH_4-emission factors for Manure Management (I)*

Allocation [%]	Animal category				
	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats
Pasture range and paddock	8	15	40	40	40
Solid storage and dry lot	88.08	83.18	60	60	60
Liquid system	3.92	1.82	-	-	-
VS (Volatile Solid Excretion Rate) [kg DM day^{-1}]	see Table 6.11	see Table 6.11	3.90	0.40	0.28
B_0 (Max CH_4-producing capacity) [m^3 kg^{-1} VS]	0.24	0.17	0.10	0.19	0.17
CH_4-emission factor [kg $head^{-1}$ yr^{-1}]	see Table 6.11	see Table 6.11	0.95	0.25	0.12

Table 6.11. *Allocation of animal manure per AWMS, volatile solid excretion rate, maximum methane producing capacity and CH_4-emission factors for Manure Management (II)*

Allocation [%]	Animal category				
	Horses	Asses and Mules	Swine	Total Poultry	Rabbits
Pasture range and paddock	40	40	-	-	-
Solid storage and dry lot	60	60	25	74	100
Liquid system	-	-	25	26	-
Pit storage <1 month	-	-	25	-	-
Pit storage >1 month	-	-	25	-	-
VS (Volatile Solid Excretion Rate) [kg DM day^{-1}]	1.72	0.94	0.50	0.019	-
B_0 (Max CH_4-producing capacity) [m^3 kg^{-1} VS]	0.33	0.33	0.45	0.32	-
CH_4-emission factor [kg $head^{-1}$ yr^{-1}]	1.39	0.76	10.87	0.16	0.08

Note that Pit storage is reported together with the Liquid system in the CRF table 4.B(a)s2.

6.3.2.3 Emission factors

Emission factors for CH_4

CH_4 emission factors for manure management were calculated in accordance with the GPG (IPCC, 2000) (Equation 4.17):

$$EF_i = VS_i * 365 * B_{oi} * 0.67 * \Sigma_{(jk)} MCF_{jk} \bullet MS_{ijk} \qquad \text{(Equation 6.3)}$$

Where

EF_i emission factor for livestock population i [kg $head^{-1}$ yr^{-1}]

VS_i volatile solid excretion for livestock population i [kg $head^{-1}$ day^{-1}]

365 Factor-1 [day yr^{-1}]

B_{oi} maximum CH_4 producing capacity for manure produced by animals in livestock population i [m^3 kg^{-1} VS]

0.64 Factor-1 [kg m^{-3}]

MCF_{jk} CH_4 conversion factors for each manure management system j by climate region k [kg kg^{-1}]
MS_{ijk} fraction of animal species/category i's manure handled using manure system j in climate region k

Table 6.96.10, 6.11 and 6.12 contain parameters used for the calculations (VS, B_o, MCF, MS) and the CH_4 emission factors.

Volatile solid excretion per day (VS) – VS for "Dairy Cattle" and "Non-Dairy Cattle" was calculated according to the GPG (IPCC, 2000) (Equation 4.16, page 4.31).

$$VS = GE \bullet (1\ \text{kg-dm}/18.45\ \text{MJ}) \bullet (1 - DE/100) \bullet (1 - ASH/100)$$

Where
VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm $head^{-1}$ day^{-1}
GE = Estimated daily average feed intake in MJ $head^{-1}$ day^{-1}
DE = Digestible energy of the feed in percent
ASH = Ash content of the manure in percent

The "Estimated daily average feed intake in MJ/day (GE)" value was calculated on the basis provided in Chapter 6.2.2.1. In order to estimate the value "digestible energy of the feed in percent (DE)" the concentrate % (see 6.2.2.1) were used as follows:

Concentrate %	DE %
13.00 – 16.99	65.0
17.00 – 22.00	67.5
Over 22.00	70.0

In the case of poultry the volatile solid excretion rates for each year were determined according to the livestock composition. The poultry category in the Hungarian agricultural inventory contains layers, broilers, turkeys, ducks, gees and guinea fowl populations. The annual values of VS for the poultry population were determined as the overall weighted mean of the VS values provided in the Table 10A.9 of the Guidelines (IPCC, 2006). In the case of geese and guinea fowl IPCC default values for VS are not provided, therefore values provided for ducks and broilers were used, respectively. The annual livestock population and VS values for the subcategories of poultry are shown in Table 6.12.

Table 6.12. *Animal population and VS for poultry livestock in 2009*

Livestock	Annual population in 2009 [1000 head]	VS/day [kgVS]
Chicken	22,365	0.01
Laying hen	12,732	0.02
Geese	2,385	0.02
Ducks	3,736	0.02
Turkeys	3,422	0.07
Guinea fowls	149	0.01
Total poultry	44,789	0.019

For the other livestock categories the IPCC default values of VS provided by the Table B-2 and B-7 in the Rev. Guidelines (IPCC, 1996) were used.

Maximum CH_4 producing capacity (B_o) values – since there are no country specific values available, in accordance with the recommendation of the GPG (IPCC, 2000), the default values listed in Appendix B-4 of the Rev Guidelines (IPCC, 1996) were used.

CH_4 conversion factors (MCF) – since there are no country specific values available, the IPCC default values (GPG 2000, Table 10, 4.36. p.) were used.

Ash content - In the case of “Ash content” of the manure in percent (ASH)” the IPCC default value (8%) was used (GPG 2000, 4.31. p.).

Tables 6.13. and 6,14., summarise the data on volatile solid excretion rates and CH_4-emission factors for Manure Management.

Table 6.13. *Volatile solid excretion rates and CH_4-emission factors for Manure Management for Dairy Cattle and Non-Dairy Cattle 1985-2009*

Year	Dairy Cattle		Non-Dairy Cattle	
	VS (Volatile Solid Excretion Rate)	CH_4-Emission Factor	VS (Volatile Solid Excretion Rate)	CH_4-Emission Factor
	[kg DM day^{-1}]	[kg $head^{-1}$ yr^{-1}]	[kg DM day^{-1}]	[kg $head^{-1}$ yr^{-1}]
1985	4.76	6.96	2.62	1.84
1986	4.88	7.14	2.62	1.84
1987	4.93	7.21	2.62	1.84
1988	5.01	7.33	2.61	1.83
1989	4.67	6.83	2.62	1.85
1990	4.70	6.88	2.93	2.07
1991	4.94	7.22	2.87	2.02
1992	4.98	7.29	2.86	2.01
1993	4.93	7.20	2.83	1.99
1994	4.96	7.25	2.82	1.98
1995	4.72	6.90	2.82	1.99
1996	5.07	7.41	2.81	1.98
1997	4.78	6.98	2.81	1.98
1998	4.96	7.25	2.81	1.98
1999	4.94	7.22	2.81	1.98
2000	4.96	7.25	2.80	1.97
2001	5.05	7.39	2.79	1.97
2002	4.88	7.13	2.79	1.96
2003	4.88	7.13	2.81	1.98
2004	4.88	7.13	2.84	2.00
2005	5.01	7.32	2.85	2.00
2006	5.11	7.48	2.88	2.03
2007	5.20	7.60	2.90	2.04
2008	5.24	7.66	2.91	2.05
2009	5.19	7.59	2.92	2.05

Table 6.14. *Methane conversion factors for manure management systems*

Manure Management System	MCF [kg kg^{-1}]
Pasture range and paddock	0.01
Solid storage and dry lot	0.01
Liquid system	0.39
Pit storage <1 month	0.00
Pit storage >1 month	0.39
Other	0.01

Source: GPG (IPCC, 2000) Table 4.10, p.4.36
Note that Pit storage is reported together with the Liquid system in the CRF table 4.B(a)s2.

Emission factors for N_2O
Since there are no country specific factors available, the IPCC default emission factors were used (Table 6.15).

Table 6.15. *Emission factors used for the estimation of the N_2O emission from various manure management systems*

Manure management system	N_2O-N emission factor [kg N_2O-N kg^{-1} N_{ex}]
Pasture range and paddock	0.02
Solid storage and dry lot	0.02
Liquid system	0.001
Pit storage <1 month	0.001
Pit storage >1 month	0.001
Other AWMS	0.005

Source: GPG2000, Table 4-12, p. 4.43
Note that Pit storage is reported together with the Liquid system in the CRF table 4.B(a)s2.

6.3.3. Uncertainties and time-series consistency

CH_4 emissions:
Uncertainty of activity data (animal population) was estimated for each animal species for the data collection period by the HCSO. The uncertainty of the mean annual averages was estimated according to the error propagation rules. (See Table 6.3)
Uncertainty of EFs for CH_4 emissions from manure management was assumed to be ±30%, for all livestock categories, except rabbit, for which ±50% was applied. The Rev. Guideline (IPCC, 1996) suggests ±20%, the Guideline (IPCC, 2006) provides ±30% for the T1 and ±20% for T2 methods, while the CORINAIR Guidebook (EEA, 2006) suggests ±30%, therefore the ±30% is more reliable for the country-specific emission factors. The Tier1 uncertainty analysis gives an overall uncertainty of ±24 % for the CH_4 emission from manure management.
N_2O emissions:
Uncertainties of ±25% are assumed in relation to the N excretion of dairy cattle's, non-dairy cattle's and swine, for which country-specific values are used, and ±50% for the other livestock categories in accordance with the GPG (IPCC, 2000). The uncertainty of the MS data was assumed to be ±50% in accordance with the default value provided by Guideline (IPCC, 2006). The combined uncertainties of the excreted N in the different AWMSs range between 28 and 56 percent. (The smaller value refers to the Solid system, the higher one to the Pit storage system.) The uncertainty of the EFs are -50%/+100%, therefore the lower combined uncertainty of the N_2O emissions from Manure management is 56% and the upper one is 102%.

6.3.4. QA/QC Information

See 6.1.5.

6.3.5. Source-specific recalculations

The annual QC procedure revealed that the VS values for poultry used in our previous (2010) submission is approximatly one-seventh of the IPCC default values. Therefore further research has been initiated relating to the country-specific value, and before finishing the research project, this emissions are reported using the overall weighted mean of the default values provided by the Guideline (IPCC, 2006). CH_4 emissions from manure management for poultry were recalculated. Table 6.16 gives an overview of the effect of the recalculation.

***Table 6.16**. Change in CH_4 emissions from 4.B Manure Management due to recalculation of VS for Poultry*

	1985	BY	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg CH_4]	114.2	114.4	114.6	113.6	113.4	107.6	110.3	95.6	
Submission 2011 [Gg CH_4]	115.6	116.1	115.9	114.7	114.9	109.5	112.5	97.5	
Difference [Gg CH_4]	1.4	1.7	1.3	1.1	1.5	1.9	2.3	1.8	
Percentage change	1.2%	1.5%	1.1%	1.0%	1.3%	1.7%	2.0%	1.9%	
	1992	1993	1994	1995	1996	1997	1998	1999	
Submission 2010 [Gg CH_4]	79.1	72.9	63.6	65.0	69.2	63.4	67.8	69.7	
Submission 2011 [Gg CH_4]	80.6	74.7	64.9	66.6	71.0	65.2	69.7	71.6	
Difference [Gg CH_4]	1.5	1.8	1.4	1.6	1.8	1.8	1.9	1.9	
Percentage change	1.9%	2.5%	2.1%	2.5%	2.6%	2.8%	2.8%	2.7%	
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Submission 2010 [Gg CH_4]	65.1	62.7	65.2	65.0	57.3	52.8	51.6	52.6	48.6
Submission 2011 [Gg CH_4]	67.3	64.7	67.4	67.2	59.8	55.0	54.0	54.8	50.7
Difference [Gg CH_4]	2.2	1.9	2.2	2.2	2.6	2.2	2.4	2.2	2.2
Percentage change	3.3%	3.1%	3.4%	3.4%	4.5%	4.2%	4.6%	4.1%	4.5%

In the calculation sheet of N-excretion rate for Dairy Cattles a minor calculation error has been detected for the period 2006-2008. Therefore these values were corrected, and the N_2O emissions from manure management recalculated. The effect of this recalculation is negligible.

The net effect of the recalculations is shown in Table 10.2.

6.3.6. Planned improvements

Revision of data on the distribution of manure management systems is planned since serious reconstructions have been carried out in the Hungarian agriculture sector affecting manure management systems since 2007. The revision will be based on the data of General Agricultural Census conducted in 2010. The results of the Census will be published in 2011. (See also 6.1.7.)

6.4. Rice cultivation (CRF sector 4.C.)

6.4.1. Source Category Description

Emitted gas: CH_4
Key source: none

Hungary is situated on the north edge of the rice production area. According to this the climatic conditions are unfavorable. The production area of rice involves the poorer quality soils.
Since the production volume is very low in Hungary, the contribution of rice cultivation to the greenhouse gas emissions is minimal, only 0.4% of the entire CH_4 emissions from agriculture sector.

6.4.2. Methodological issues

In Hungary the rice is cultivated on poorer quality soil, without organic amendments, the fields are intermittently flooded. The aeration is applied as a pest control during the cultivation. (Apáti, 2003)
Methane emissions from rice cultivation were calculated according to the Equation 4.42 of the GPG (IPCC, 2000). Due to lack of detailed technological data on cropping technology the IPCC default factors were used for the calculation, according to the Table 4.22.
(EF= 20 g CH_4 m^{-2}; SF_0= 2; SF_s=1). For the scaling factor to water management 0.5 was applied, because of the intermittently flooded, single aeration water management technology. The total size of the production area was calculated on the basis of the official HCSO data.

6.4.3. Uncertainties and time-series consistency

See 6.1.4. and Table 6.4.
For the uncertainty of the activity data, ±5% has been estimated by expert judgement. Uncertainties of the factors used for the calculation of the emission factor were taken from the GPG (IPCC, 2000). (SF_W -60%/+40%; SF_0 -25%/150%; EF_C -40%/+40%;
SF_S -90%/+100%. Therefore the overall lower and upper uncertainty of 100% and 198% can be calculated for the emission from rice cultivation.

6.4.4. QA/QC Information

See 6.1.5.

6.4.5. Source-specific recalculations

Recalculation was not required.

6.4.6. Planned improvements

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6.5. Agricultural soils (CRF sectors 4.D.1, 4.D.2 and 4.D.3)

6.5.1. Source Category Description

Emitted gas: N_2O
Key source: Direct: Level 1, 2; Trend 1, 2;
Indirect: Level 1, 2; Trend 1, 2;
PRP: Level 2;

In 2009 agricultural soils emitted 84% of the total N_2O emissions of the agriculture sector, and 71% of the national total N_2O emissions are generated in agricultural soils. Emissions form the agricultural soils contributed 7.2 percent (4,821 Gg CO_2-eq) to the Hungarian total GHG emissions in 2009. (See table 6.2.)

The trend in emissions is decreasing. The emissions from Agricultural soils have decreased to 48 percent of the 1985-1987 levels in 2009. A significant drop occurred in the period 1985-1993 due to significant decrease in livestock population and synthetic fertilizer use which resulted in less N-input (Figure 6.5). For more details on trends see also Chapter 6.1.1.

Emissions from 4.D Agricultural soils and their trends per sub-categories are shown in Table 6.17.

Table 6.17. *Emissions and trends from the 4.D Agricultural Soils per sub-categories*

Year	N_2O emissions (Gg N_2O)							
	4.D.1	4.D.1.1	4.D.1.2	4.D.1.3	4.D.1.4	4.D.2	4.D.3.1	4.D.3.2
BY	17.7	10.4	4.3	0.8	2.3	1.1	12.4	1.9
1985	17.2	9.9	4.3	0.8	2.2	1.1	12.1	1.9
1986	17.8	10.5	4.2	0.7	2.3	1.1	12.5	1.9
1987	18.2	10.9	4.2	0.8	2.3	1.1	12.7	1.9
1988	17.6	10.2	4.0	0.9	2.5	1.0	12.0	1.8
1989	17.2	9.7	3.9	0.9	2.6	1.0	11.5	1.7
1990	13.1	6.3	3.9	0.7	2.2	0.9	8.9	1.4
1991	9.6	2.5	3.6	0.8	2.8	0.9	5.7	1.0
1992	8.0	2.6	3.0	0.6	1.8	0.8	5.3	0.9
1993	7.4	2.8	2.7	0.5	1.5	0.7	5.0	0.9
1994	8.7	3.9	2.4	0.5	1.9	0.6	5.5	0.9
1995	8.3	3.4	2.4	0.5	2.0	0.5	5.0	0.8
1996	8.6	3.6	2.3	0.5	2.2	0.5	5.1	0.8
1997	8.6	3.6	2.2	0.5	2.2	0.5	5.1	0.8
1998	9.3	4.4	2.3	0.5	2.1	0.5	5.7	0.9
1999	9.6	4.6	2.3	0.5	2.2	0.5	5.9	0.9
2000	8.8	4.6	2.3	0.3	1.6	0.6	5.9	0.9
2001	9.9	4.9	2.3	0.4	2.3	0.6	6.1	0.9
2002	9.9	5.4	2.3	0.4	1.9	0.5	6.4	1.0
2003	9.3	5.1	2.3	0.3	1.6	0.6	6.3	1.0
2004	10.5	5.2	2.2	0.4	2.7	0.6	6.3	1.0
2005	9.7	4.6	2.1	0.4	2.6	0.6	5.7	0.9
2006	9.9	5.1	2.0	0.4	2.4	0.6	6.1	0.9
2007	9.7	5.7	2.0	0.3	1.7	0.6	6.4	1.0
2008	10.1	5.2	2.0	0.4	2.6	0.6	6.0	0.9
2009	9.3	4.9	1.9	0.4	2.2	0.6	5.7	0.9
Trend BY-2009	-47.7%	-53.3%	-55.7%	-53.2%	-5.3%	-53.9%	-53.9%	-54.1%

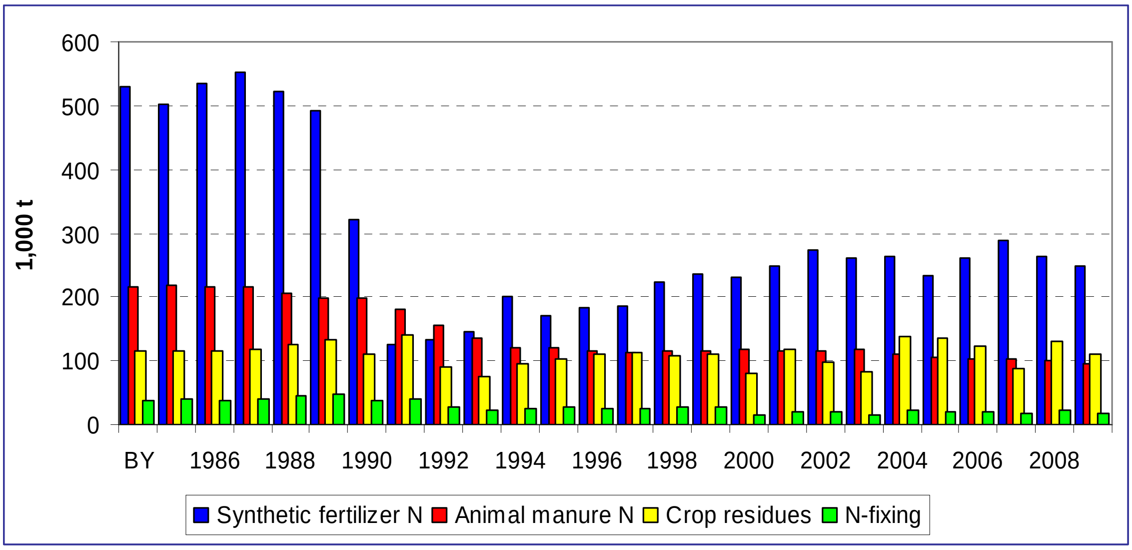

Figure 6.5. *Trends from N-inputs from synthetic fertilizer, animal manure, crop residues and N-fixing*

6.5.2. Methodological issues

The estimation of direct and indirect N_2O emissions was carried out on the basis of the GPG (IPCC, 2000) using the Tier 1b method, Equation 4.29 (IPCC, 2000).

The activity data such as livestock population (Table 6.5) for calculating N-excretion, total harvested production of plants (Table 6.20), synthetic N-fertilizer use (Table 6.18) were obtained directly from the database of the HCSO.

Table 6.18. *Synthetic fertilizer use (1985-2009)*

Year	Synthetic fertilizer use [1,000 t]
BY	589
1985	558
1986	593
1987	614
1988	579
1989	548
1990	358
1991	140
1992	148
1993	161
1994	222
1995	191
1996	203
1997	206
1998	248
1999	262
2000	258
2001	275
2002	303
2003	289
2004	293

Year	Synthetic fertilizer use [1,000 t]
2005	260
2006	289
2007	320
2008	294
2009	275

Source: HCSO, 2010

N_2O emissions from the categories of Direct Soil Emissions (from synthetic N-fertilizer, animal manure, N-fixing, crop residues), Emissions from Pasture, Range and Paddock Manure and Indirect Soil Emissions were calculated with the parameters summarized in Table 6.14 and 6.15. In order to calculate the amount of N from animal manure use and on pastures the data of Table 6.8, 6.9, 6.10, and 6.11. (see also chapter 6.3.2) were also used beside Table 6.18.

The parameters used for the calculation of N fixed by N fixing crops and N-input from crop residues were selected on the basis of the GPG (IPCC, 2000) default values (Table 4.16, Page 4.58). In the case of crops that are not listed in the above mentioned table, the parameters for similar type of crop were chosen (e.g. the factors for bean in the case of French bean). If a default residue nitrogen content were not provided in Table 4.16, the non-crop specific default value listed in Table 4-19 of the Rev. Guideline (IPCC, 1996) was applied.

Table 6.19. *Parameters and values used for the calculation of N_2O emissions from Agricultural Soils*

Parameter	Dimension	Value
Direct Soil Emissions – Synthetic Fertilizer		
$Frac_{GASF}$	kg kg^{-1}	0.1
F_{SN}	kg yr^{-1}	GPG Eq-4.22
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Animal Manure		
$Frac_{GASM}$	kg kg^{-1}	0.2
$Frac_{FUEL-AM}$	kg kg^{-1}	0
$Frac_{PRP}$ (2009)	kg kg^{-1}	0.126
$Frac_{FEED-AM}$	kg kg^{-1}	0
$Frac_{CNST-AM}$	kg kg^{-1}	0
F_{AM}	kg yr^{-1}	GPG Eq-4.24
EF_1	kg kg^{-1}	0.0125

Direct Soil Emissions – N-Fixing		
$Res_{BF}/Crop_{BF}$		Table 6.20
$Frac_{DM}$ N-fixing-crops		Table 6.20
$Frac_{NRCBF}$		Table 6.20
F_{BN}		
Non-forage Crops	kg yr^{-1}	GPG Eq-4.26
Forage Crops	kg yr^{-1}	GPG Eq-4.27
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Crop Residues		
$Res_O/Crop_O$		Table 6.20
$Frac_{DM}$, N-fixing and Non-N-fixing Crops		Table 6.20
$Frac_{NCRO}$		Table 6.20
$Res_{BF}/Crop_{BF}$		Table 6.20
$Frac_{NCRBF}$	kg kg^{-1}	Table 6.20
$Frac_{BURN}$	kg kg^{-1}	0
$Frac_{BURN}$ for Cereals 1985-1989		0.1103-0.0220
$Frac_{FUEL-CR}$	kg kg^{-1}	0
$Frac_{CNST-CR}$	kg kg^{-1}	0
$Frac_{FOD}$	kg kg^{-1}	0
F_{CR}	kg yr^{-1}	GPG Eq-4.26
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Pasture, Range and Paddock Manure		
$Frac_{PRP}$ (2009)	kg kg^{-1}	0.126
EF_3	kg kg^{-1}	0.02
Indirect Soil Emissions – Atmospheric deposition		
$Frac_{GASF}$	kg kg^{-1}	0.1
$Frac_{GASM}$	kg kg^{-1}	0.2
EF_4	kg kg^{-1}	0.01
Indirect Soil Emissions – Leaching and Run-Off		
$Frac_{LEACH}$	kg kg^{-1}	0.3
EF_5	kg kg^{-1}	0.025

Table 6.20. *Crop production and crop residue statistics used to estimate emissions from N-fixing and crop residues*

Crop	Annual Crop Product	Residue/ Crop Product Ratio	Dry Matter Fraction	Nitrogen Fraction
	[t]	[t/t]	[t/t]	[t N/ t dm]
Wheat	4,419,163	1.3	0.850	0.0028
Meslin	277	1.3	0.850	0.0028
Maize	7,528,380	1.0	0.780	0.0081
Rice	11,722	1.4	0.850	0.0067
Barley	1,063,881	1.2	0.850	0.0043
Rye	72,531	1.6	0.900	0.0048
Oats	111,144	1.3	0.920	0.0070
Triticale	360,719	1.3	0.850	0.0028
Other cereals	22,545	1.3	0.850	0.0028
Potatoes	560,615	0.4	0.850	0.0110
Bean	937	2.1	0.855	0.0230
Peas	32,506	1.5	0.870	0.0142
Lentil	24	2.1	0.855	0.0230
Broad bean	125	2.1	0.855	0.0230
Lupin	556	2.1	0.855	0.0230
Soybeans	71,587	2.1	0.865	0.0230
Sunflower seed	1,256,185	1.0	0.850	0.0150
Rape seed	579,365	1.0	0.850	0.0150
Linseed	948	1.0	0.850	0.0150
Poppy seed	3,458	1.0	0.850	0.0150
Sugar-beet	737,014	0.3	0.850	0.0228
Lucerne seed	377	1.3	0.850	0.0150
Seeds of grass	681	1.3	0.850	0.0150
Tomatoes	192,810	0.4	0.850	0.0110
Cucumber	51,694	0.4	0.850	0.0110
Watermelon	220,426	0.4	0.850	0.0110
Melon	12,283	0.4	0.850	0.0110
Green peas	98,501	1.5	0.870	0.0142
Green beans/ French beans	26,327	2.1	0.855	0.0230
Sweet pepper	148,775	0.4	0.850	0.0110
Bonnet pepper	19,032	0.4	0.850	0.0110
Sweet corn	421,704	1.0	0.780	0.0081
Hungarian red paprika	19,982	0.4	0.850	0.0110
Lucerne hay	612,969	0.0	0.850	0.0150
Red clover hay	14,468	0.0	0.850	0.0150

6.5.3. Uncertainties and time-series consistency

For the uncertainty of the synthetic fertilizer nitrogen ±5% has been estimated by expert judgment. Uncertainty for $Frac_{GASF}$ (±50%) was taken from the CORINAIR Guidebook (EEA, 2007). The combined uncertainty of the F_{SN} is 50%. A combined uncertainty of ±79% can be estimated for F_{AM}. (Combined uncertainty of 15.7% resulted for the total N excreted by livestock, the uncertainty for the $Frac_{GASM}$ is -75%/ +100% in accordance with the GPG (IPCC, 2000). For the uncertainty of the F_{BN} resulted in ±40%, while the uncertainty of the F_{CR} ±25% was taken from the CORINAIR Guidebook (EEA, 2006) due to lack of detailed information. The resulting uncertainty for the activity data of the direct soil emission is 31.5%. The uncertainty of the emission factor is -80%/ +380% in accordance with the GPG (IPCC, 2000). The resulting uncertainty ranges for the direct emission of the agricultural soil from 86% to 381%. The resulting uncertainty ranges for the indirect emission of the agricultural soil from 72% to 149%.

6.5.4. QA/QC Information and verification

For the general procedure of the QC see 6.1.5.
In 2010 a detailed quality control and verification processes were carried out in relation to the 4.D.1.3 N-fixing Crops and 4.D.1.4 Crop Residues. The following activities were conducted:

- The crop production data used were compared to the original HCSO's crop production statistics.
- Checking and removing data gaps
- Crop residue statistics used in 4.D.1.3 were cross-checked with 4.D.1.4
- Crop residue statistics were compared with the values presented in Table 4.16 of GPG (IPCC, 2000)
- Crop residue statistics used in the calculation were compared with corresponding statistics reported in the NIRs of the other surrounding countries (Austria, Croatia, Romania, and Slovenia) and the values published in Table 4.16 of the GPG (IPCC, 2003). The results of the comparison are shown in Table 6.21-6.23.

The results of the QC and verification activities were documented in a special QC report.

Table 6.21. *Verification of residue to crop product ratios used to estimate emissions from crop residues and N-fixing*

Product	Residue/ Crop Product Ratio					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Wheat	1.3	1.0	1.3	1.3	1.3	1.3
Meslin	1.3	no data	*1.3*[1]	*1.3*[2]	no data	no data
Maize	1.0	1.4	1.0	1.0	1.0	1.0
Rice	1.4	no data	1.4	no data	no data	1.4
Barley	1.2	1.1	1.2	1.2	1.2	1.2
Rye	1.6	1.4	1.3	1.6	no data	1.6
Oats	1.3	1.5	1.3	1.3	1.3	1.3
Triticale	1.3	no data	*1.3*[1]	1.6	no data	no data
Other cereals	1.3	no data	*1.3*[1]	*1.3*[2]	no data	no data
Potatoes	0.4	0.3	0.4	0.4	0.4	0.4
Beans	2.1	*1.5*[3]	2.1	*2.1*[4]	no data	2.1
Peas	1.5	1.0	*1.5*[5]	1.2	no data	1.5
Lentil	2.1	no data	*2.1*[6]	no data	no data	no data
Broad bean	2.1	1.5[3]	*2.1*[6]	no data	no data	no data

Product	Residue/ Crop Product Ratio					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Lupin	2.1	no data	*2.1*[6]	no data	no data	no data
Soybeans	2.1	1.5	2.1	1.4	no data	2.1
Sunflower seed	1.0	2.5	no data	1.3	1.3	no data
Rape seed	1.0	21.0	no data	no data	1.0	no data
Linseed	1.0	no data	no data	no data	no data	no data
Poppy seed	1.0	no data	no data	no data	no data	no data
Sugar-beet	0.3	0.8	0.2	1.4	1.4	no data
Lucerne seed	1.0	no data	no data	no data	no data	no data
Seeds of grass	1.0	no data	no data	no data	no data	no data
Tomatoes	0.4	no data	no data	1.0	1.0	no data
Cucumber	0.4	no data	no data	1.0	no data	no data
Watermelon	0.4	no data	no data	no data	no data	no data
Melon	0.4	no data	no data	no data	no data	no data
Green peas	1.5	*0.4*[7]	no data	*1.2*[7]	no data	*1.5*[7]
Green beans/ French beans	2.1	*1.5*[3]	no data	1.2	no data	*2.1*[8]
Sweet pepper	0.4	no data	no data	no data	no data	no data
Bonnet pepper	0.4	no data	no data	no data	no data	no data
Sweet corn	1.0	no data	no data	no data	no data	no data
Hungarian red paprika	0.4	no data	no data	no data	no data	no data
Lucerne hay	0.0	no data	no data	no data	no data	no data
Red clover hay	0.0	0.0	no data	no data	no data	no data

Source: NIR of Austria, 2010; NIR of Romania, 2010; NIR of Slovenia, 2010; NIR of Croatia. 2010; Table 4.16 of GPG (IPCC, 2000)
Note: [1]Other grains, [2]Other cereals, [3]Fodderbean, [4]Dry beans, [5]Pea beans, [6]Other leguminous, [7]Peas, [8]Beans.

Table 6.22. *Verification of dry matter fractions used to estimate emissions from crop residues and N-fixing*

Product	Dry Matter Fraction					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Wheat	0.850	0.86	0.85	0.86	0.86	0.82-0.88
Meslin	0.850	no data	*0.85*[1]	*0.86*[2]	no data	no data
Maize	0.780	0.50	0.40	0.86	0.86	0.70-0.86
Rice	0.850	no data	0.85	no data	no data	0.82-0.88
Barley	0.850	0.86	0.85	0.86	0.86	0.82-0.88
Rye	0.900	0.86	0.85	0.86	no data	0.90
Oats	0.920	0.86	0.85	0.86	0.92	0.92
Triticale	0.850	no data	*0.85*[1]	0.86	no data	no data
Other cereals	0.850	no data	*0.85*[1]	*0.86*[2]	no data	no data
Potatoes	0.850	0.30	0.45	0.19	0.30	no data
Beans	0.855	*0.40*[3]	0.85	*0.895*[4]	no data	0.82-0.89
Peas	0.870	0.40	*0.85*[5]	0.15	no data	0.87
Lentil	0.855	no data	*0.85*[6]	no data	no data	no data
Broad bean	0.855	*0.40*[3]	0.85[6]	no data	no data	no data
Lupin	0.855	no data	*0.85*[6]	no data	no data	no data
Soybeans	0.865	0.40	0.85	0.86	no data	0.84-0.89
Sunflower seed	0.850	0.86	no data	0.86	0.92	no data

Product	Dry Matter Fraction					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Rape seed	0.850	0.86	no data	no data	0.90	no data
Linseed	0.850	no data	no data	no data	no data	no data
Poppy seed	0.850	no data	no data	no data	no data	no data
Sugar-beet	0.850	0.45	0.15	0.25	0.25	*no data*
Lucerne seed	0.850	no data	no data	no data	no data	no data
Seeds of grass	0.850	no data	no data	no data	no data	no data
Tomatoes	0.850	no data	no data	0.063	0.063	no data
Cucumber	0.850	no data	no data	0.037	no data	no data
Watermelon	0.850	no data	no data	no data	no data	no data
Melon	0.850	no data	no data	no data	no data	no data
Green peas	0.870	*0.40*[7]	no data	*0.15*[7]	no data	*0.87*[7]
Green beans/ French beans	0.855	*0.40*[3]	no data	0.15	no data	*0.82-0.89*[8]
Sweet pepper	0.850	no data	no data	no data	no data	no data
Bonnet pepper	0.850	no data	no data	no data	no data	no data
Sweet corn	0.780	no data	no data	no data	no data	no data
Hungarian red paprika	0.850	no data	no data	no data	no data	no data
Lucerne hay	0.850	no data	no data	no data	no data	no data
Red clover hay	0.850	0.86	no data	no data	no data	no data

Source: NIR of Austria, 2010; NIR of Romania, 2010; NIR of Slovenia, 2010; NIR of Croatia. 2010; Table 4.16 of GPG (IPCC, 2000)

Note: [1]Other grains, [2]Other cereals, [3]Fodderbean, [4]Dry beans, [5]Pea beans, [6]Other leguminous, [7]Peas, [8]Beans.

Table 6.23. *Verification of Nitrogen fractions used to estimate emissions from crop residues and N-fixing*

Product	Nitrogen Fraction					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Wheat	0.0028	0.005	0.012	0.0028	0.0028	0.0028
Meslin	0.0028	no data	*0.012*[1]	*0.0150*[2]	no data	no data
Maize	0.0081	0.005	0.020	0.0081	0.0081	0.0081
Rice	0.0067	no data	0.014	no data	no data	0.0067
Barley	0.0043	0.005	0.015	0.0043	0.0043	0.0043
Rye	0.0048	0.005	0.012	0.0048	no data	0.0048
Oats	0.0070	0.005	0.015	0.0070	0.0070	0.0070
Triticale	0.0028	no data	*0.012*[1]	*0.0150*[2]	no data	no data
Other cereals	0.0028	no data	*0.012*[1]	*0.0150*[2]	no data	no data
Potatoes	0.0110	0.012	0.015	0.0110	0.0110	0.0110
Beans	0.0230	*0.025*[3]	0.015	*0.0300*[4]	no data	no data
Peas	0.0142	0.038	*0.015*[5]	0.0142	no data	0.0142
Lentil	0.0230	no data	*0.015*[6]	no data	no data	no data
Broad bean	0.0230	no data	*0.015*[6]	no data	no data	no data
Lupin	0.0230	no data	*0.015*[6]	no data	no data	no data
Soybeans	0.0230	0.023	0.050	0.0230	no data	0.0230
Sunflower seed	0.0150	0.009	no data	0.0150	0.0150	no data
Rape seed	0.0150	0.009	no data	no data	0.0150	no data
Linseed	0.0150	no data	no data	no data	no data	no data
Poppy seed	0.0150	no data	no data	no data	no data	no data

Product	Nitrogen Fraction					
	Hungary	Austria	Romania	Slovenia	Croatia	IPCC default
Sugar-beet	0.0228	0.800	0.015	0.0150	0.0150	no data
Lucerne seed	0.0150	no data	no data	no data	no data	no data
Seeds of grass	0.0150	no data	no data	no data	no data	no data
Tomatoes	0.0110	no data	no data	0.0150	0.0150	no data
Cucumber	0.0110	no data	no data	0.0150	no data	no data
Watermelon	0.0110	no data	no data	no data	no data	no data
Melon	0.0110	no data	no data	no data	no data	no data
Green peas	0.0142	*0.038*[7]	no data	*0.0142*[7]	no data	*0.0142*[7]
Green beans/ French beans	0.0230	*0.025*[3]	no data	0.0300	no data	no data
Sweet pepper	0.0110	no data	no data	no data	no data	no data
Bonnet pepper	0.0110	no data	no data	no data	no data	no data
Sweet corn	0.0081	no data	no data	no data	no data	no data
Hungarian red paprika	0.0110	no data	no data	no data	no data	no data
Lucerne hay	0.0150	no data	no data	no data	no data	no data
Red clover hay	0.0150	0.018	no data	no data	no data	no data

Source: NIR of Austria, 2010; NIR of Romania, 2010; NIR of Slovenia, 2010; NIR of Croatia. 2010; Table 4.16 of GPG (IPCC, 2000)
Note: [1]Other grains, [2]Other cereals, [3]Fodderbean, [4]Dry beans, [5]Pea beans, [6]Other leguminous, [7]Peas, [8]Beans.

6.5.5. Source-specific recalculations

Revision of the nitrogen excretion rate for dairy cattle for 2006-2008 resulted in change of the activity data in 4.D1.2 Animal Manure Applied to Soils, 4.D2 Agricultural Soils/ Direct N_2O-Emissions/ Pasture, Range and Paddock Manure and 4.D3. Agricultural Soils/ Indirect N_2O-Emissions.
Filling the data gaps in the datasets of harvested production for lucerna seed for 1996-2006 and for lentil, lupin and broad bean for 2006-2008 resulted in change in the emissions from 4.D1.3 N-fixing crops Agricultural Soils/ Direct N_2O-Emissions for the period 1996-2008.
Minor revision of activity data in 4.D1.4 Crop Residues due to filling the data gaps in the datasets of harvested production for meslin for 2006-2008 also contributed to the change in the emission from the agricultural soils.
Some inconsistencies in the use of the crop residues statistics in 4.D.1.3 were also removed, and a transcription error relating to the Residue to Crop product ratio ($Res_0/Crop_0$) for rice was also corrected in the calculation of the emission from 4.D.1.4 in the time-series 1985-2008.
The overall effect of the recalculations on the emissions from 4.D is negligible. The changes in emissions range between 0.01 to 0.03 Gg N_2O.

The net effect of the recalculations are shown in Table 10.2.

6.5.6. Planned improvements

Elaboration of country-specific values for all livestock categories regarding N-excretion.
In the course of the annual QC activity revealed that the increasing harvested production of the sunflower and rapeseed resulted in increasing emissions from these biofuels in Hungary. In addition to the GPG (IPCC, 2000) does not provide default parameters for the estimation of the emission from the crop residues of these plants. From the comparison of the NIR of the surrounding countries of Hungaries revealed that the different countries reports very different values for these parameters. E.g. the value of the residue to crop product ratio for the rape seed in the Austrian inventory is 21-times higher than in the Hungarian inventory.

Therefore a research project on the development of country specific parameters for the sunflower seed and rape seed has been initiated.

6.6. Field burning of agricultural residues (CRF Sector 4.F.)

6.6.1. Source Category Description

Emitted gases: CH_4, N_2O
Key source: none

In Hungary field burning of agricultural residues has been bound to permit by the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers being in force between 1986 and 2001. The condition for a permit was the case of plant health emergency. The Government Decree No. 21/2001. (II. 14.), which came into force in 2001 explicitly bans field burning of agricultural residues (the new regulation still keeps the possibility of field burning in the case of plant health emergency by a permit). So according to the abovementioned facts it was thought that there is no legal field burning in Hungary since the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers has come into force. According to the estimation of the regional inspectors of the Central (Budapest) Soil and Plant Protection Service, less than 1% of the area sown by crops (i.e., not the entire arable area) is affected by illegal burning (Sári 2003, verbal communication), therefore it was taken into account only between 1985 and 1989, and it was considered as negligible in the period after 1990.

6.6.2. Methodological issues

Until the middle of the 1980s, field burning was quite wide-spread. In the lack of reliable and quantitative information, it was assumed that the rate of field burning in crop cultivation areas had been gradually decreasing between 1985 and 1989, and was essentially eliminated in 1990. Accordingly, for the mentioned period between 1985 and 1990 the following values for crops were used as the proportion of biomass burnt on field: $Frac_{BURN}$ = 0.11, 0.09, 0.07, 0.04 and 0.02 (it meant for all plants produced: $Frac_{BURN}$ = 0.05, 0.04, 0.03, 0.02 and 0.01). As regards other parameters required for the calculation (dry matter, product/by-product ratio, C to N ratio), the default values indicated in the Revised Guidelines (Ref. Manual, Table 4-17, p. 4.65, p. 4.83) were used.

6.6.3. Uncertainties and time-series consistency

See 6.1.4. and Table 6.1.

6.6.4. QA/QC Information

See 6.1.5.

6.6.5. Source-specific recalculations

Recalculation was not required.

6.6.6. Planned improvements

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6.7. References

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7. Land-Use, Land-Use Change and Forestry (CRF sector 5.)

7.1. Overview of sector

7.1.1. Emission trends

The greenhouse gas inventory of the Land Use, Land-Use Change and Forestry (LULUCF) sector comprises emissions and removals of CO_2 due to overall carbon gains or losses in the relevant carbon pools of the predefined six land-use categories. The liming of agricultural lands is included in the LULUCF sector, as well. The non-CO_2 emissions from biomass burning and disturbance associated with land-use conversion to cropland are also to be reported here. These activities altogether resulted in 3,019 Gg net removal of CO_2 equivalent in 2009. The estimated emissions and removals by gases over the period 1985-2009 are presented in Table 7.1.

Table 7.1 *Emissions and removals by gas from LULUCF 1985-2009 (Gg)*

Year	GHG emissions/ removals [Gg]				
	CO_2	CH_4	N_2O	NO_x	CO
BY	-2,199	1.46	0.02	0.29	10.16
1985	-86	1.47	0.02	0.29	10.20
1986	-3,038	1.49	0.02	0.29	10.33
1987	-3,474	1.44	0.03	0.28	9.95
1988	-4,461	1.40	0.03	0.27	9.65
1989	-3,671	1.39	0.04	0.27	9.63
1990	-1,991	1.29	0.05	0.25	8.89
1991	-2,293	1.26	0.05	0.25	8.66
1992	-3,359	1.16	0.05	0.23	7.93
1993	-5,319	1.04	0.05	0.20	7.00
1994	-5,790	1.06	0.06	0.20	7.16
1995	-5,825	1.10	0.07	0.21	7.48
1996	-1,913	1.19	0.08	0.23	8.13
1997	-2,085	1.21	0.08	0.24	8.28
1998	-3,117	1.19	0.09	0.23	8.07
1999	-1,484	1.02	0.10	0.24	8.55
2000	-428	1.48	0.11	0.33	11.45
2001	-1,769	1.33	0.11	0.29	10.35
2002	-968	1.31	0.11	0.30	10.41
2003	-3,130	1.27	0.11	0.29	10.27
2004	-2,187	1.10	0.11	0.25	8.89
2005	-4,293	1.71	0.12	0.40	14.16
2006	-2,344	1.02	0.11	0.25	8.93
2007	-2,754	1.51	0.11	0.36	12.74
2008	-3,988	1.12	0.10	0.25	8.90
2009	-3,072	1.11	0.10	0.25	8.76
Trend BY-2009 (%)	39.67	-24.51	335.59	-0.14	-0.14

The LULUCF sector was a net sink of CO_2 in Hungary in all the years from 1985 to 2009. Forest Land is a net carbon sink, whereas Grassland and Settlements are net sources of greenhouse gases and Cropland is a net source in some years and a net sink in other years. In 2009, removals from LULUCF corresponded to 4.5 percent of total GHG emissions in Hungary (excluding LULUCF), compared to its 1.9 % in the base year. The variability of removals from LULUCF was rather high over the period 1985-2009, as shown in Table 7.2.

Table 7.2 *Trends in CO_2-eq emissions/removals from LULUCF by land-uses 1985-2009)*

Year	GHG emissions/ removal [Gg]				
	5. LULUCF Total	5.A Forest Land	5.B Cropland	5.C Grassland	5.E Settlements
BY	-2,162	-2,907	669	15	61
1985	-50	-1,356	1,214	33	60
1986	-3,000	-3,466	383	21	61
1987	-3,435	-3,899	410	-10	63
1988	-4,421	-4,149	-327	-10	65
1989	-3,629	-2,886	-807	-4	67
1990	-1,950	-2,552	473	33	97
1991	-2,252	-2,869	442	111	65
1992	-3,320	-3,586	99	115	52
1993	-5,281	-5,203	-283	127	78
1994	-5,749	-5,713	-301	196	70
1995	-5,781	-5,775	-325	236	84
1996	-1,865	-1,873	-325	257	77
1997	-2,034	-2,150	-254	284	86
1998	-3,064	-3,126	-315	284	93
1999	-1,433	-1,492	-324	287	96
2000	-364	-475	-308	273	145
2001	-1,707	-1,959	-150	265	136
2002	-906	-1,446	119	269	152
2003	-3,068	-3,559	56	267	168
2004	-2,129	-2,594	-15	274	206
2005	-4,221	-4,683	59	260	144
2006	-2,289	-2,709	-11	265	165
2007	-2,688	-2,996	-81	258	130
2008	-3,933	-4,122	-194	251	132
2009	-3,019	-3,193	-230	248	156
Share in Hungarian total, in BY	1.9%	2.6%	0.6%	0.01%	0.05%
Share in Hungarian total, in 2009	4.5%	4.8%	0.3%	0.4%	0.2%
Trend BY-2009	40%	10%	-134%	1548%	154%

The most important sub-category as the main source of removal in the sector is 5.A Forest Land. The bulk of the CO_2 removal is generated in living biomass in 5.A.1 Forest Land remaining Forest Land category. The large sink is mainly due to the fact that the total increment of the growing stock in forest lands is always higher than the annual harvest. The total net emissions from the other land-use categories is less than 1% of the national total,

and amounts to 12% of the removal in Forest Land on average.
Although the reported emissions/removals from 5.B Cropland, 5.C Grassland and 5.E Settlements are insignificant, but their trends are significant, particularly for Grassland as shown in Table 7.2. The long-term growth in the emissions from Grassland is determined principally by the change in the grassland management as a result of the drop of grazing animal livestock after the change of the regime at the beginning of the nineties (for more details see Chapter 6.1.1 and Chapter 7.4). It is also to be noted that trends in the emissions from Grassland and Settlements are exaggerated due to the impact of the 20-year rolling period starting in 1985. In accordance with the GPG for LULUCF (IPCC, 2000), a unit of land subject to a change of use remains in the conversions sub-category for 20 years before it is reported in the remaining sub-category of the new land-use category to which it has been converted. The land-use conversions have been taken into account since 1985 for Hungary, which results a slightly decreasing, and significantly increasing trends in the area of the "remaining" and the "converted to" sub-categories of the different land-uses, respectively. The increasing trends in the area of the conversion categories over the period 1985-2005 resulted in exaggerated increasing trends in the emissions from Settlements and Grassland. In the case of Forest Land the conversion period is country-specific; therefore this saturation problem does not influence the trend in the emissions/removals. The trend in emission from Cropland only partly reflects this problem as a result of different compensatory processes in the emissions and removals within the sub-sector.
It should be noted that the land-use conversions that have been taken into account since 1985 have no influence on the trends after 2005. On the other hand emissions from the 5.B, 5.C and 5.E are small and their effect on overall trend in national total is negligible.

The increase in carbon stocks in living biomass in the category 5.A Forest Land was 877 Gg C in 2009. The living biomass in Cropland was a source of 66 Gg C due to the higher removal than plantation in vineyards and orchards, while mineral soils were sink of 139 Gg C as a result of the abandonment of 6,664 ha cropland. Grassland was a source of 67 Gg C due to the continuously decreasing area of improved grasslands. While the total area of Grassland is decreasing, the area of Settlements is increasing, which resulted in an emission of 43 Gg C in 2009. Liming in agricultural soils contributed 11 Gg CO_2 to the emissions in 2009. In addition, the non-CO_2 emissions from biomass burning were 1.11 Gg CH_4 and 0.01 Gg N_2O. In this category the controlled burning of slash in Forest Land and the wildfires in Forest Land, Cropland and Grassland are reported. The other source of N_2O emissions is the disturbance associated with land-use conversion to cropland, which amounted to 0.09 Gg N_2O in 2009

7.1.2. Completeness

In the inventory submission in 2011 Hungary reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 5.A), Cropland (CRF 5.B), Grassland (CRF 5.C) and Settlements (CRF 5E). In category 5.A Forest Land carbon stock change in living biomass is reported. In categories 5.B Cropland, 5.C Grassland and 5.E Settlements carbon stock changes in living biomass, dead organic matter and mineral soils are reported. N_2O emissions from fertilization (CRF 5(I)) are reported under the Agriculture sector (CRF 4). N_2O emission from soil disturbance associated with land-use conversion to cropland is also to be reported in CRF table 5(III). In addition, CO_2 emission from liming is reported in CRF table 5(IV) and CO, CH_4, N_2O and NO_x emissions from biomass burning are reported in CRF table 5(V).
In 2010 further improvements has been conducted to improve completeness of the Hungarian LULUCF sector. Emissions from wildfires in Cropland and Grassland categories were previously not reported due to lack of appropriate data but now they are included for the whole time series. Emissions from Cropland and Grassland converted to Settlements (CRF 5.E.2.2 and 5.E.2.3) were not reported either in our previous submissions, and they are also included for the first time in this submission. Carbon stock change in dead organic matter

from Forest Land converted to other land-use are included in the Hungarian inventory for the first time in this submission, as well.
The LULUCF sector report does not include emission estimates from Wetlands (CRF 5.D) and Other Land (CRF 5F). In these categories only area data are reported. Other Land is unmanaged; therefore emissions from this category are not reported. Non-CO_2 emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported as drainage is a very rare activity in Hungary. Emissions from organic soils are not reported either because organic soils are not in use for agricultural purposes.
The coverage of the LULUCF sector is presented in Table 7.3.

***Table 7.3** Completeness of LULUCF sector*

GHG source and sink categories	CO_2	CH_4	N_2O
5.A. Forest Land			
1. Forest Land remaining Forest Land	R	R	R
2. Land converted to Forest Land	R	NO	NO
5.B Cropland			
1. Cropland remaining Cropland	R	R	R
2. Land converted to Cropland	R	IE, NO	R
5.C Grassland			
1. Grassland remaining Grassland	R	R	R
2. Land converted to Grassland	R	IE, NO	IE, NO
5.D Wetlands			
1. Wetlands remaining Wetlands	NE[1], NO	NO	NO
2. Land converted to Wetlands	NE, NO	NE, NO	NE, NO
5.E Settlements			
1. Settlements remaining Settlements	NE[2]	NA	NA
2. Land converted to Settlements	R	NA	NA
5.F Other Land			
1. Other Land remaining Other Land			
2. Land converted to Other Land	NE[3]	NA	NA
5(I) Direct N_2O emissions from N fertilization			NO
5(II) Non-CO_2 emissions from drainage of soils and Wetlands		NE, NO	NE, NO
5(III) N_2O emissions from disturbance associated with land-use conversions to cropland			R
5(IV) CO_2 emissions from agricultural lime application	R		
5(V) Biomass burning	IE, NA, NO	R	R

Legend: R=reported
[1,2]Parties may decide not to prepare estimates for these categories.
[3]Other Land is considered unmanaged, therefore not reported.

7.1.3. Methodology

The IPCC Tier 2 methodology (i.e. country-specific wood-density), provided by the GPG for LULUCF (IPCC, 2003) is used for the estimation of emissions/removals from living biomass of Forest Land, while Tier 1 methodology is used in the case of other pools and land-use categories.
For representing land areas a mix of the IPCC Approach 1 and 2 methods is used. The National Forest Inventory provides activity data for the forest land, which are suitable for using higher Approaches, but in case of the other land-uses the most reliable dataset can be achieved by combining the Approach 1 land-use statistics with land-cover change databases. Detailed descriptions of the applied methodologies are provided in Chapter 7.2-7.8, the

foregoing two chapters summarize the main information about the land area representation as well as the activity data of the estimations and the emission factors used.

7.1.3.1. Land area representation used in the Hungarian Inventory

The key activity data to provide emission estimation for land-use changes are the land areas according to the consistent area representation recommended by the GPG (IPCC, 2003). This chapter presents a description of data sources of the land area representation, the national application of the IPCC land-use categories and the resulted land-use change matrices. (For the detailed methodological description on the compilation of land-use change matrices see Annex A3.4.)

Following the recommendations of the 2010 in-country review of Hungary's national inventory, the land-use classification has been reconsidered and the set-aside croplands and the set-aside grasslands were reallocated from the Other Land category into the Cropland and the Grassland category. This reconsideration of the land areas resulted in significant change in the reported areas and emissions in the 5.B Cropland, 5.C Grassland and the 5.F Other Land categories.

The land-use categories in the Hungarian inventory are consistent with the GPG for LULUCF (IPCC, 2003) requirements. The reported land area is the average of the official land area of Hungary published by the HCSO's land-use statistics (9,303,266 ha). There are little changes in the annually reported total land area in land-use statistics due to movements of natural borders of Hungary and improvements of mapping techniques. To avoid inconsistency, the average of the annually published total areas is reported in the GHG inventory.

Coverage of the IPCC land-use categories required the compilation of different activity data from different statistical surveys in Hungary.

The main sources of activity data were the National Forest Inventory (Central Agricultural Office Forest Directorate), the land-use statistics of the Hungarian Central Statistical Office (HCSO), the CORINE Land Cover inventories referring to 1990, 2000 and 2006 (CLC90, CLC2000 and CLC2006, respectively) and the CORINE Land Cover-change databases referring to 1990-2000 and 2000-2006 (CLC-changes$_{1990\text{-}2000}$, CLC-changes$_{2000\text{-}2006}$) as well as the results of satellite image processing implemented for GHG inventory purposes for 1985 and 1985-1990 (HLC85 and HLC-Changes$_{1985\text{-}1990}$ databases).

The forest inventory (based on which the National Forestry Database, NFD is maintained) provides the data for our estimates for Forest land. NFD comprises data on the whole forested area of the country regardless of ownership. The survey is continuous; approximately 10 percent of the whole forested area is renewed annually, and the whole forested area is thus surveyed in a 10-year-long cycle. The inventory is stand-based, the average size of a forest compartment is about 4 ha, and the spatial resolution of mapping of forests is 0.1 ha. The NFD did not provide information on land-use categories before afforestation and after deforestation until 2007. The initial and final land-use data have been collected since 1 January 2008.

The second most important data source is the HCSO's land-use statistics. The annual census is published via the internet, on the website of the HCSO (http://portal.ksh.hu/pls/ksh/docs/eng/agrar/html/tabl1_3_1.html). The HCSO's land-use statistics records the whole official area of the country divided into nine land-use categories, which are as follows: Arable land, Kitchen garden, Orchard, Vineyard, Grassland, Forest, Reed, Fishpond, Uncultivated land area. The data refer to those areas that are declared to be 'in use' under the specified nine land-use categories by agricultural enterprises and private farms. Lands not in use for agricultural purposes are reported aggregately as uncultivated land area. The data acquisition is based on questionnaires, and land-use data are available since 1853, although there have been changes in the methodology since the beginning of the data collection (Kecskés, 1997). To ensure consistency, the data set was adjusted according to the methodological changes. (It is important to note, that the Forest area reported by the HCSO differs from the CAO, Forestry Directorate data because of differences in data collection and the Forest area definition. Forest areas reported by the

HCSO are not used for GHG inventory purposes. The HCSO's data refer to the areas of land that are 'in use' therefore areas that not covered by trees are not reported as forests in this statistics.)
The HCSO's land-use statistics is the unique unified land-use data set for Hungary for the whole inventory time series. It represents the whole area of the country but as its background is an agricultural survey, it does not contain information on Settlements, and Wetlands. (However, Fishponds and Reeds are reported in it, but these categories represent only small parts of the IPCC Wetlands category.) Settlements and Wetlands are rather land cover than land-use categories therefore they were determined using the CLC, HLC, CLC-change, and HLC-change databases. The annual data were interpolated from these databases.
The HCSO's land-use statistics do not contain information on land-use changes, only the net area data for the different categories are available. Unified data set for land-use changes for the whole inventory period was not available, but the HLC-changes$_{1985-1990}$, CLC-changes$_{1990-2000}$, CLC-changes$_{2000-2006}$ datasets contain information on the land-cover changes for the all IPCC categories. Nevertheless, the difference between the 'land-use' and 'land-cover' can cause some discrepancies. The two CLC-change databases were supplemented by a third, auxiliary land-cover change database for the years of 1985-1990 (HLC-Changes$_{1985-1990}$). This data set is similar to the other CLC-change datasets and it was produced via processing satellite images specifically for GHG inventory purposes by the Institute of Geodesy, Cartography and Remote Sensing. For more details see the technical documentation of the project (FÖMI, 2009b). It is important to note that the minimal extension of the mapped area is 25 ha in the CLC and HLC databases, but 5 ha in the CLC-change and HLC-change databases. (FÖMI, 2004; FÖMI, 2009a; FÖMI 2009b)
In the compilation of land-use change matrices, the different statistical surveys were treated hierarchically, as follows:

1. National Forestry Database
2. HCSO land-use statistics
3. Land cover databases

National application of IPCC land use categories in the Hungarian inventory and land use change matrices

Forest
Forest is defined in Hungary as a land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. On the other hand, „forest land" includes forests, as well as roads and other areas that are under forest management, but that are not covered by trees.
Regarding the data sources, the activity data were taken from the National Forestry Database of the Central Agricultural Office Forest Directorate (the former National Forest Service).

Cropland
Cropland area contains the arable lands, kitchen garden[3], orchards and the vineyard areas, which are reported in the "land area of Hungary by land use categories" statistics of the HCSO. The definitions of the four above mentioned subcategories are the following:
Arable land: any land area under regular cultivation irrespective of the soil cultivation and whether the area is under crop production or not due to any reason, such as inland waters or fallow. Area under tree nurseries (including ornamental and orchard tree nurseries, vineyard nurseries, forest tree nurseries, but excluding those for the holdings' own requirements grown in the forest), permanent crops (e.g. alfalfa and strawberries), herbs and aromatic crops are included. Area of kitchen gardens utilized for crop and horticultural production is

[3] In Hungarian terms kitchen garden means vegetable garden.

included only if it is not devoted for the own consumption of the people living on the holding.
Kitchen garden is usually an area around the house separated from the rest of the farm used primarily for production for the own consumption of people belonging to the farm; any surplus of low amount is for selling.
Orchard: land area under fruit trees and bushes, where the main crops are fruit trees and bushes. Orchard area may include several fruit species (e.g.: apples, pears, cherries, etc.) orchard includes not productive orchards as well. In the framework of statistical observation orchard land use category includes coherent orchards in kitchen gardens (with equal row width and plant spacing), if the area is 200 m^2 or above in case of berries and 400 m^2 or above in case of fruit trees.
Vineyard areas, where the grapes are planted in equal row width and planting space and the main crops are grapes. Vineyard can include more grape varieties, and includes not productive areas as well. Vineyard also includes vineyard areas in kitchen gardens (trellises), if the area is planted coherently (equal row width and planting space) and is at least of 200 m^2 in area.
Cropland category contains the set-aside Croplands as well. The annual area of set-aside croplands were estimated from the compilation of the HCSO land-use statistics and the CLC-change databases.

Grassland
Grassland area refers to the Grassland (meadow and pasture) area which is reported in the "Land area of Hungary by land use categories" statistics of HCSO. Land area utilized as meadow or pasture is reported here.
Meadow: land area under grass (artificial planting included), and the production is utilized by cutting, irrespective of whether it is used for grazing sometimes.
Pasture: land area under grass (artificial planting included) utilized for grazing irrespective of whether it is used for cutting sometimes. Land areas under grass with trees utilized for grazing are included.
It should be noted; that this category contains the natural grasslands (set-aside grasslands) which are not in use for agricultural purposes. The annual area of set-aside grasslands were estimated from the compilation of the HCSO land-use statistics and the CLC-change databases.

Wetlands
Wetland area matches with the wetlands and water body categories of the CORINE land-cover databases. It contains the inland marshes (low-lying land usually flooded in winter, and more or less saturated by water all year round), peat bogs (peat land consisting mainly decomposed moss and vegetable matter. May or may not be exploited), water courses (natural or artificial water-courses including those serving as water drainage), water bodies (natural or artificial lakes, ponds etc.).
This category contains all the wetlands in Hungary. For separation of peat lands and flooded lands as managed wetlands by GPG for LULUCF (IPCC, 2003), further data are needed. (The most peat land areas are protected in Hungary, thus the peat extraction has been rolled back over the recent decades. Peat extraction is negligible in Hungary.)

Settlements
This category matches with the 'Artificial surfaces' category of the CORINE land-cover database, which comprises the urban areas, industrial, commercial and transport units; mine, dump and construction sites and artificial non agricultural vegetated areas.

Other Land
This category matches with the 'Open spaces with little or no vegetation' category of the CORINE land-cover database, which comprises the sparsely vegetated areas, which includes even less vegetation, than the natural grassland category.

Table 7.4 shows the land-use changes over the period 1985 to 2009 in the form of land-use change matrices for the individual years relative to the official national area of Hungary. It should be noted that a rolling 20-year transition period that began in 1985 was taken into account in the calculation of the areas of the remaining and converted to categories. In the Forest Land category the transition period depends on tree species, therefore data of the Land converted to Forest Land categories in the next table differ from those that are reported in the CRF Table 5.A.2 Land converted to Forest Land. The next matrices provided activity data for the estimation of emission from carbon stock change in mineral soils in Cropland, Grassland and Settlements categories. For the estimation of carbon stock change in living biomass, the annual conversions were taken into account instead of areas calculated using the 20-year transition period. Details of implementation of land-use change matrices are reported in Annex A3-4.

***Table 7.4** Land use matrices 1985-2009 (ha)*

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Forest Land	1,740,962	95	21	0	210	0
Cropland	11,166	5,472,249	5,338	129	838	0
Grassland	3,379	4,910	1,281,051	169	391	0
Wetlands	16	0	0	254,272	14	0
Settlements	118	9	117	23	525,344	0
Other Land	0	0	0	0	0	2,444
1985	**1,755,640**	**5,477,264**	**1,286,527**	**254,593**	**526,798**	**2,444**
Forest Land	1,740,636	190	42	0	421	0
Cropland	19,168	5,457,942	10,675	258	1,677	0
Grassland	5,800	9,821	1,273,159	338	782	0
Wetlands	27	0	0	254,246	29	0
Settlements	202	19	235	47	525,109	0
Other Land	0	0	0	0	0	2,444
1986	**1,765,833**	**5,467,971**	**1,284,111**	**254,889**	**528,018**	**2,444**
Forest Land	1,740,309	284	63	0	631	0
Cropland	27,676	5,448,466	10,675	387	2,515	0
Grassland	8,375	17,186	1,262,659	507	1,173	0
Wetlands	38	0	0	254,220	43	0
Settlements	292	28	352	70	524,869	0
Other Land	0	0	0	0	0	2,444
1987	**1,776,691**	**5,465,966**	**1,273,749**	**255,185**	**529,232**	**2,444**
Forest Land	1,739,983	379	83	0	842	0
Cropland	36,228	5,438,947	10,675	516	3,354	0
Grassland	10,963	24,552	1,252,145	676	1,564	0
Wetlands	50	0	0	254,194	57	0
Settlements	382	38	470	94	524,628	0
Other Land	0	0	0	0	0	2,444
1988	**1,787,607**	**5,463,916**	**1,263,373**	**255,480**	**530,446**	**2,444**
Forest Land	1,739,657	474	104	0	1,052	0
Cropland	46,995	5,427,212	10,675	645	4,192	0
Grassland	14,221	31,918	1,240,961	845	1,956	0
Wetlands	65	0	0	254,165	72	0
Settlements	496	47	587	117	524,364	0
Other Land	0	0	0	0	0	2,444
1989	**1,801,435**	**5,459,651**	**1,252,328**	**255,772**	**531,636**	**2,444**
Forest Land	1,739,044	654	145	0	1,445	0
Cropland	56,945	5,416,294	10,675	775	5,031	0
Grassland	17,232	39,283	1,230,024	1,014	2,347	0
Wetlands	79	0	0	254,136	86	0
Settlements	601	57	704	141	524,109	0
Other Land	0	0	0	0	0	2,444
1990	**1,813,902**	**5,456,288**	**1,241,549**	**256,066**	**533,017**	**2,444**
Forest Land	1,738,805	714	158	0	1,612	0
Cropland	65,877	5,390,382	26,688	904	5,869	0
Grassland	19,935	39,283	1,226,762	1,183	2,738	0
Wetlands	92	0	0	254,110	100	0
Settlements	696	66	822	164	523,864	0
Other Land	0	0	0	0	0	2,444
1991	**1,825,404**	**5,430,445**	**1,254,429**	**256,360**	**534,184**	**2,444**
Forest Land	1,738,679	758	167	0	1,684	0
Cropland	75,813	5,363,465	42,701	1,033	6,708	0
Grassland	22,941	39,283	1,223,195	1,352	3,129	0
Wetlands	105	0	0	254,082	114	0
Settlements	800	76	939	188	523,609	0
Other Land	0	0	0	0	0	2,444
1992	**1,838,339**	**5,403,582**	**1,267,002**	**256,654**	**535,244**	**2,444**
Forest Land	1,738,350	771	250	0	1,917	0
Cropland	82,518	5,348,918	49,409	1,230	7,646	0
Grassland	24,303	47,552	1,213,120	1,498	3,426	1
Wetlands	123	0	0	254,055	123	0
Settlements	1,044	104	1,117	204	523,143	0
Other Land	0	0	0	0	0	2,444
1993	**1,846,338**	**5,397,345**	**1,263,895**	**256,988**	**536,255**	**2,445**

***Table 7.4** (continued) Land use matrices 1985-2009 (ha)*

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
1993	**1,846,338**	**5,397,345**	**1,263,895**	**256,988**	**536,255**	**2,445**
Forest Land	1,738,132	799	277	0	2,080	0
Cropland	87,366	5,336,228	56,116	1,428	8,583	0
Grassland	25,287	55,821	1,203,422	1,645	3,724	2
Wetlands	136	0	0	254,034	131	0
Settlements	1,220	132	1,295	220	522,745	0
Other Land	0	0	0	0	0	2,444
1994	**1,852,141**	**5,392,980**	**1,261,109**	**257,327**	**537,263**	**2,446**
Forest Land	1,737,774	852	337	0	2,324	0
Cropland	95,125	5,320,626	62,824	1,625	9,521	0
Grassland	26,862	64,090	1,193,132	1,792	4,021	2
Wetlands	157	0	0	254,005	139	0
Settlements	1,502	160	1,472	236	522,242	0
Other Land	0	0	0	0	0	2,444
1995	**1,861,421**	**5,385,729**	**1,257,765**	**257,658**	**538,247**	**2,447**
Forest Land	1,737,428	931	416	0	2,512	0
Cropland	103,716	5,304,193	69,531	1,822	10,458	0
Grassland	28,607	72,359	1,182,674	1,939	4,319	3
Wetlands	180	0	0	253,974	147	0
Settlements	1,814	188	1,650	252	521,708	0
Other Land	0	0	0	0	0	2,444
1996	**1,871,746**	**5,377,671**	**1,254,271**	**257,987**	**539,144**	**2,447**
Forest Land	1,736,906	1,123	507	0	2,751	0
Cropland	113,656	5,286,411	76,238	2,020	11,396	0
Grassland	30,625	80,628	1,171,942	2,085	4,616	4
Wetlands	207	0	0	253,939	156	0
Settlements	2,175	216	1,827	268	521,125	0
Other Land	0	0	0	0	0	2,444
1997	**1,883,569**	**5,368,378**	**1,250,515**	**258,312**	**540,044**	**2,448**
Forest Land	1,736,504	1,212	548	0	3,023	0
Cropland	122,347	5,269,877	82,946	2,217	12,333	0
Grassland	32,390	88,897	1,161,463	2,232	4,913	5
Wetlands	230	0	0	253,907	164	0
Settlements	2,491	245	2,005	284	520,587	0
Other Land	0	0	0	0	0	2,444
1998	**1,893,962**	**5,360,231**	**1,246,963**	**258,641**	**541,021**	**2,449**
Forest Land	1,736,109	1,239	639	0	3,301	0
Cropland	133,575	5,250,807	89,653	2,415	13,271	0
Grassland	34,669	97,165	1,150,470	2,379	5,211	6
Wetlands	260	0	0	253,869	172	0
Settlements	2,899	273	2,183	300	519,958	0
Other Land	0	0	0	0	0	2,444
1999	**1,907,512**	**5,349,484**	**1,242,945**	**258,962**	**541,912**	**2,450**
Forest Land	1,735,390	1,307	696	0	3,896	0
Cropland	145,149	5,231,390	96,361	2,612	14,209	0
Grassland	37,019	105,434	1,139,406	2,526	5,508	6
Wetlands	291	0	0	253,830	180	0
Settlements	3,320	301	2,360	316	519,315	0
Other Land	0	0	0	0	0	2,444
2000	**1,921,170**	**5,338,432**	**1,238,822**	**259,283**	**543,108**	**2,451**
Forest Land	1,734,869	1,368	796	0	4,254	0
Cropland	158,779	5,213,644	98,208	2,916	16,174	0
Grassland	39,498	108,419	1,133,305	2,625	6,047	6
Wetlands	302	0	0	253,784	216	0
Settlements	3,496	302	2,479	346	518,988	0
Other Land	0	0	0	0	0	2,444
2001	**1,936,944**	**5,323,733**	**1,234,789**	**259,670**	**545,679**	**2,451**

Table 7.4 *(continued) Land use matrices 1985-2009 (ha)*

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
2001	**1,936,944**	**5,323,733**	**1,234,789**	**259,670**	**545,679**	**2,451**
Forest Land	1,734,232	1,477	886	0	4,694	0
Cropland	174,565	5,193,742	100,056	3,220	18,139	0
Grassland	42,370	111,404	1,126,812	2,724	6,585	6
Wetlands	313	0	0	253,737	251	0
Settlements	3,701	304	2,598	376	518,634	0
Other Land	0	0	0	0	0	2,444
2002	**1,955,180**	**5,306,926**	**1,230,351**	**260,056**	**548,302**	**2,451**
Forest Land	1,733,638	1,503	930	0	5,217	0
Cropland	185,427	5,178,764	101,903	3,524	20,103	0
Grassland	44,345	114,388	1,121,215	2,822	7,123	6
Wetlands	321	0	0	253,693	287	0
Settlements	3,842	305	2,717	406	518,343	0
Other Land	0	0	0	0	0	2,444
2003	**1,967,573**	**5,294,960**	**1,226,764**	**260,445**	**551,073**	**2,451**
Forest Land	1,732,694	1,577	1,049	0	5,968	0
Cropland	197,364	5,162,710	103,751	3,828	22,068	0
Grassland	46,516	117,373	1,115,422	2,921	7,661	6
Wetlands	330	0	0	253,649	322	0
Settlements	3,997	306	2,836	435	518,038	0
Other Land	0	0	0	0	0	2,444
2004	**1,980,902**	**5,281,966**	**1,223,056**	**260,833**	**554,057**	**2,451**
Forest Land	1,746,962	1,553	1,055	0	6,070	0
Cropland	188,531	5,161,275	100,260	4,002	23,195	0
Grassland	43,562	115,447	1,116,851	2,851	7,808	6
Wetlands	316	0	0	253,933	343	0
Settlements	3,909	298	2,837	442	519,312	0
Other Land	0	0	0	0	0	2,444
2005	**1,983,280**	**5,278,574**	**1,221,003**	**261,229**	**556,729**	**2,451**
Forest Land	1,756,972	1,503	1,055	0	6,303	0
Cropland	193,662	5,149,041	96,770	4,177	24,321	0
Grassland	43,529	113,522	1,116,317	2,781	7,955	6
Wetlands	315	0	0	254,210	364	0
Settlements	3,995	290	2,838	448	520,446	0
Other Land	0	0	0	0	0	2,444
2006	**1,998,472**	**5,264,356**	**1,216,980**	**261,616**	**559,391**	**2,451**
Forest Land	1,767,911	1,425	1,070	0	6,285	0
Cropland	202,691	5,134,858	98,618	4,352	25,448	0
Grassland	44,144	109,141	1,109,644	2,711	8,102	6
Wetlands	316	0	0	254,483	386	0
Settlements	4,132	282	2,840	455	521,523	0
Other Land	0	0	0	0	0	2,444
2007	**2,019,194**	**5,245,705**	**1,212,171**	**262,001**	**561,744**	**2,451**
Forest Land	1,778,859	1,428	1,085	0	6,235	0
Cropland	204,116	5,128,234	100,465	4,527	26,574	0
Grassland	43,371	104,760	1,104,345	2,641	8,250	6
Wetlands	312	0	0	254,761	407	0
Settlements	4,171	274	2,841	461	522,698	0
Other Land	0	0	0	0	0	2,444
2008	**2,030,830**	**5,234,696**	**1,208,736**	**262,390**	**564,163**	**2,451**
Forest Land	1,792,557	1,390	1,167	0	6,320	0
Cropland	200,854	5,124,082	102,312	4,702	27,701	0
Grassland	41,478	100,379	1,099,497	2,571	8,397	6
Wetlands	303	0	0	255,042	428	0
Settlements	4,155	266	2,843	468	523,905	0
Other Land	0	0	0	0	0	2,444
2009	**2,039,347**	**5,226,117**	**1,205,819**	**262,782**	**566,751**	**2,451**

Figure 7.1 shows the distribution of the net areas of the six, broad IPCC land-use categories in Hungary in 2009. Cropland is the dominant land-use category in all years, accounting for 56 percent of the total area of Hungary in 2009, followed by the Forest Land accounting for 22 percent. Grassland is the next largest at 13 percent, followed by Settlements category at 6 percent, the next one is the Wetlands category at 3 percent and the smallest one is the Other Land at 0.03 percent of the total. The major land-use changes since 1985 have been the abandonment of Croplands and Grasslands and the afforestation of abandoned Croplands. 513 thousand hectares Cropland and 473 thousand hectares Grassland were abandoned, and the Forest Land area increased by 284 thousands hectares over the period from 1985-2009.

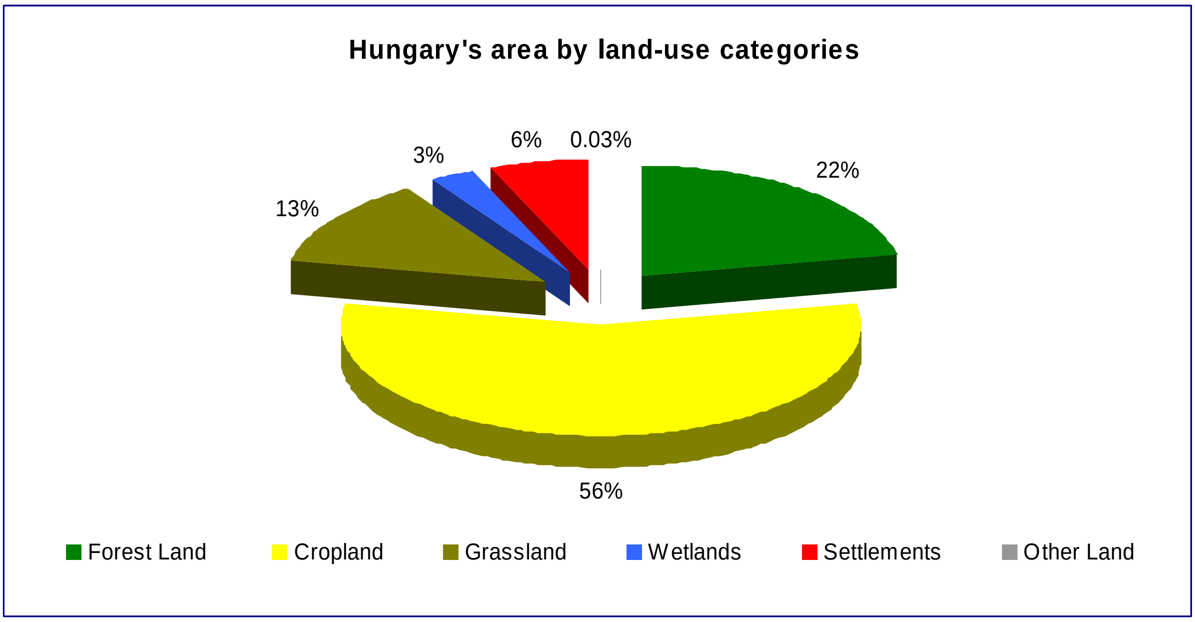


***Figure 7.1** Distribution of IPCC land-use categories in Hungary in 2009*
Note: Proportion of the Other Land is 0.03%.

7.1.3.2. Emission factors

In the estimations for Forest Land, country-specific factors were used wherever possible, and the IPCC default ones in a few cases. For the other land-use categories the IPCC default emission factors provided by the GPG (IPCC, 2003) were used, except Settlements where the default emission factor from the 2006 IPCC Guidelines (IPCC, 2006) was applied.

7.2. Forest Land (CRF sector 5.A)

A general description of the Hungarian forests and forestry in English can be found at http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT. Further data and information, mainly in Hungarian, can also be found on the website of the Central Agricultural Office Forest Directorate at http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag. Further data and information were also used that are not at the website, rather, in documents that are found in the documentation of the inventory.

Forest land covers more than one fifth of the terrestrial area of the country. The total forest land area includes forest sub-compartments that at least potentially are covered by trees, as well as unstocked areas like roads, openings, wildlife forage grounds, glades, buildings serving forest management purposes etc.). The area of forest land using this definition was 2,039.3 thousand ha by the end of 2009. Note that, earlier, we only reported the stocked area (see below), however, beginning with 2010, we report the total land under forest management as forest land, and this area is reported in the land-use change matrix.

The total area of all forest sub-compartments (i.e. the potentially stocked area) amounted to 1,912.9 thousand ha. The area actually covered by trees (i.e. the actually stocked area), which appears in several official Hungarian statistics, amounted to 1,853.2 thousand ha. This area is calculated from that of the forest sub-compartments by adjusting for gaps and overlaps in the canopy closure.

As mentioned above, both in the graphs in this report, and in the CRF tables, the total forest area is reported, however, the carbon stock changes actually take place in the forest compartments, thus, the implied emission factor and m^3/ha data should reflect the area of forest sub-compartments.

Table 7.5 *The area of forest land, forest compartments and land covered by trees (ha).*

Reporting year	Total forest area (forest subcompartments and other)	Area of forest subcompartments	Calculatad area covered by trees
1985	1,755,640	1,643,276	1,505,764
1986	1,765,833	1,650,576	1,513,582
1987	1,776,691	1,659,381	1,526,395
1988	1,787,607	1,666,586	1,530,587
1989	1,801,435	1,665,551	1,551,138
1990	1,813,902	1,681,467	1,563,585
1991	1,825,404	1,694,546	1,570,750
1992	1,838,339	1,708,804	1,589,760
1993	1,846,338	1,713,763	1,599,669
1994	1,852,141	1,719,146	1,608,811
1995	1,861,421	1,727,223	1,616,716
1996	1,871,746	1,737,818	1,627,588
1997	1,883,569	1,748,358	1,642,288
1998	1,893,962	1,758,645	1,656,399
1999	1,907,512	1,773,247	1,657,827
2000	1,921,170	1,787,372	1,689,401
2001	1,936,944	1,803,922	1,697,940
2002	1,955,180	1,823,377	1,723,805
2003	1,967,573	1,836,429	1,749,246
2004	1,980,902	1,850,809	1,769,988

Reporting year	Total forest area (forest subcompartments and other)	Area of forest subcompartments	Calculatad area covered by trees
2005	1,983,280	1,853,183	1,789,648
2006	1,998,472	1,869,349	1,805,801
2007	2,019,194	1,890,866	1,825,953
2008	2,030,830	1,903,360	1,840,171
2009	2,039,347	1,912,917	1,853,170

Of all the forests, more than 700 thousand ha were established since 1930. After periods of slow increase of forest area, afforestations have been recently intensified (Figure 7.2.) Forest management has also a long history in the country, and most forests are more or less intensively managed. Finally, there are no unmanaged forests in the country. There are some forests where no forestry operations have taken place for about two decades to a century. These are called forest reserves, however, they only occupy a few thousand ha, i.e. 0.5% of all forests, and even these forests are managed: forest monitoring, inspecting, forest protection, forest tourism and game management take place even in these forests. Therefore, all reported forests of Hungary are considered as managed.

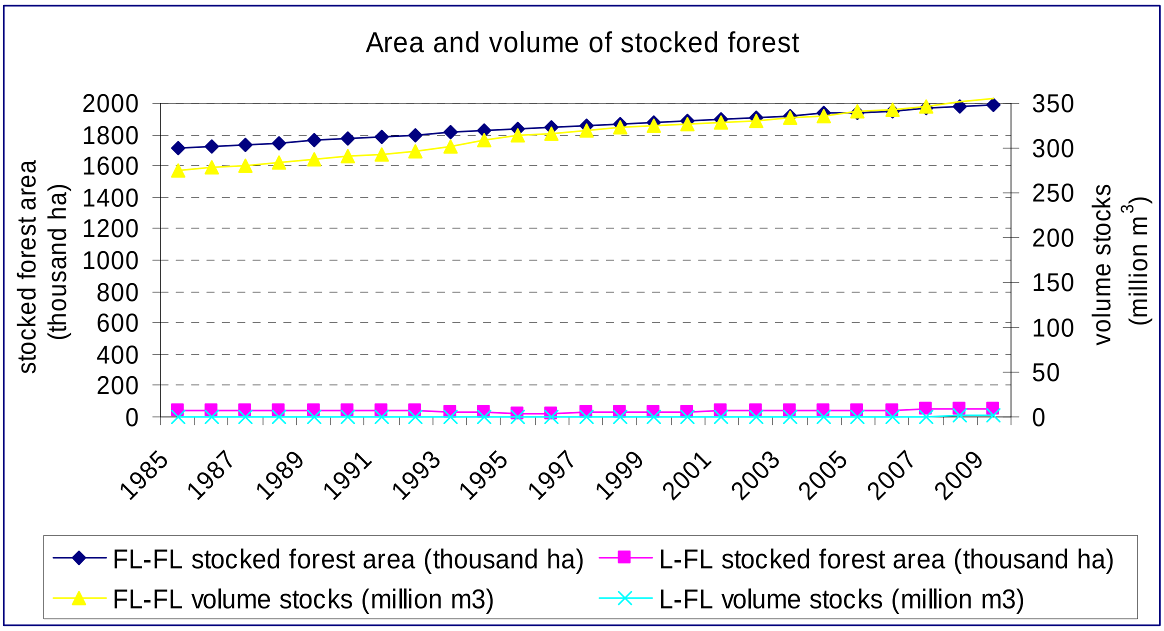


Figure 7.2 *Area and volume of stocked forest on land remaining forest land (FL-FL) and in the transition category land converted to forest land (L-FL). Note that the values of L-FL are rather small, but not zero.*

Forest management planning, as well as forest inspection is quite intensive in the country. In addition, there is a *continuous forest inventory* in the country. The units of the planning (the so called sub-compartments, which are also referred to here as stands), as well as the inventory are stands of about four ha of size on average. During planning, practically all *forest stands are surveyed once in every 10 years*, which makes it possible to track the fate of all stands, and thus that of all forest land. The survey produces detailed maps (analog maps from the late 1970s and digital ones based on GIS-interpretation since 2005), as well as a detailed dendrologic description of the forest stands (e.g. species, mean breast height diameter, mean height, stock volume, number of trees, basal area, crown closure, volume increment etc.).
Due to the intensive forest monitoring as described above, *all forest stands are continuously*

accounted for. This also means that all changes in the biomass carbon stocks of the forests due to any causes from growth through harvests, natural disturbances and deforestation (see below) are captured by the forestry statistics of each stand at least on a decade scale, and those of the whole forest area even on an annual basis. The forest inventory statistics include, and always included, all losses of volume stocks due to all deforestations. *Carbon stock changes due to deforestations are thus reported separately in this inventory.*
For this report, the Forest Directorates (i.e. units of the forest authority) estimated and reported the annual amount of both deforestations and afforestations. On an area basis, deforestation is rather small, its area being under 500ha/year on average in the last decades, which is about 0.03% of the forest area and about 5% of the average rate of afforestation. The annual rate of afforestations, i.e. land conversion to forest, amounts to some 9 kha annually. The reason for these area dynamics is that the Hungarian Forest Law is really rather rigorous and is also rather strictly implemented with respect to the deforestations, whereas afforestations are needed to increase forest resources. Also, forest owners are obliged to cover the costs of a new afforestation of the same area to offset the deforestation.

***Table 7.6**.* The area of, and emissions from, deforestations. The area has been slightly increasing because of intensive highway building of the last few years.

Inventory year	Conversions from FL to other land use	
	Area (ha)	CO_2 emissions from biomass (Gg)
1985	326.1	41.0
1986	326.1	41.0
1987	326.1	41.0
1988	326.1	41.0
1989	326.1	41.0
1990	612.9	77.1
1991	239.8	30.1
1992	125.6	15.8
1993	328.6	41.2
1994	218.2	27.4
1995	357.8	44.8
1996	345.9	43.3
1997	522.0	65.6
1998	402.0	50.2
1999	395.4	49.4
2000	719.1	89.7
2001	520.9	64.9
2002	637.5	79.4
2003	593.3	73.9
2004	943.8	117.4
2005	411.1	51.1
2006	508.6	63.2
2007	245.5	30.5
2008	293.8	27.1

Inventory year	Conversions from FL to other land use	
	Area (ha)	CO_2 emissions from biomass (Gg)
2009	455.0	58.0

We note that, in general, we used the IPCC 2006 Guidelines as a methodological basis for the development of the GHG inventory. We selected these 2006 Guidelines over the GPG (IPCC 2003) because the 2006 Guidelines are clearer with respect to the description of the methodology, it contains more and updated default values, updated scientific basis, while it is basically consistent with the GPG. Also, the 2006 Guidelines provide more flexibility with respect to accounting for land in the Land converted to Forest Land category because the 2006 Guidelines allow for a transition period of less than 20 years, and this option is consistent with our land statistics by which we can easily and practicably separate areas in this category from areas in the Forest Land remaining Forest Land category. Finally, the IPCC 1996 Revised Guidelines are also used to obtain estimates for emissions related to fires.
In general, we apply Tier 2 methodology with country specific data where we have any. We also apply “best estimates”, i.e. we have made use of all data that exist within the country.
With respect to data sources, the activity data was taken from the *National Forest Database and related forestry databases*. These databases contain data by species or species group and age class. Some emission/removal factors, e.g. wood density, are available by species or species group from literature, while only IPCC default values were available for other factors (see below).

Below there is a summary of all definitions that are generally applied in the methodology to estimate emissions and removals in the forest land category.

“Forest” (the area actually or potentially covered by trees) is defined in Hungary as a land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. On the other hand, „forest land” includes forests, as well as roads and other areas that are under forest management but that are not covered by trees (see Table 7.5).

“Afforestations” or “*reforestations”* are activities that lead to conversion of non-forest land to forest land. The conversion can take place in a period of 3-15 years, depending on tree species and site.

“Deforestation” is a conversion of forest land to non-forest land, which takes place within one year.

“Above-ground biomass” is the total biomass of trees taller than two meters above the stump, including all branches and bark.

We also note here that, in this GHG inventory, annual changes in both the area and the annual emissions and removals in the Forest Land category are classified into four groups of subcategories. This is one more than the three ones that can be defined by the various IPCC guidelines, which are the following: Forest Land remaining Forest Land (FL-FL), land converted to FL subcategory (L-FL; the conversions being afforestations and reforestations), and FL converted to other land uses (the conversions being deforestations). The introduction

of the fourth group is necessary in order to comply with the guidance of the 2006 Guidelines which says (section 4.2.1.1) that “Subsequent inventories must also allow identical area coverage in order to get reliable results when using the stock-difference method”.
In principle, all changes in the FL-FL subcategory are due to afforestations/reforestations and deforestations. In Hungary, however, areas of these conversions in total are less than the changes between total forest areas between two consecutive years. In other words, the forest inventory each year identifies (“finds”) additional forest areas, which are relatively large, on average about half of annual afforestations (Figure 11.1).

From a statistical and database point of view, only those areas can be regarded as “forest” in any inventory year that the forest inventory system “knows” that they exist. It must be underlined here that the forest inventory system in Hungary, just like that in most other countries, was designed and run in the last several decades to capture the *area* that is deemed to be forest according to laws and regulations in effect at the time, and not to capture *changes* of this area. Any changes were only registered as a result of different *mechanisms* that were *required by law*, such as subsidizing afforestations, or inspecting the implementation of the Forest Act in effect, i.e. closely monitoring deforestations. This especially was meant to scrutinize deforestations, and resulted in a limited extent of forest area reductions that could not be captured.

On the other hand, there were processes that resulted in an “increase” of the forest area over the past decades that were only captured at subsequent forest surveys, and which were not regarded so much important to track. The majority of these “increases” is due to the following causes:

- natural expansion of the forest area (about 20% of the cases),
- re-classification of land (i.e., areas of “croplands”, “grasslands” or “settlements” etc. that are found to be covered by trees are reclassified as “forests”, about 60% of the cases)
- geodesic re-measurements of stands at subsequent surveys (about 20% of the cases).

The found changes of the total forest area in any inventory year are thus only partly physical and actual increases of the “forest” area, and partly are due to the continuous development of the forest inventory. The forests that are “found” in an inventory year are termed and classified as “found forests” (FF). FF often come into existence due to unknown reasons, but often to unregistered earlier afforestations, and to natural expansion of the forest area.
Most stands in the FF category have been identifiable individually since 2008, their area being 4,798 and 4,303 ha, and their average growing stock being 126.9 and 121.9 m^3ha^{-1} in 2008 and 2009, respectively. The remaining parts of the changes in the total forest area are due to unregistered or illegal afforestations and any other changes as identified by the remeasurement of forest area by the continous forest inventory.
For earlier inventory years, we only identified the total area of FF, and conducted a sampling of management plans to establish their specific growing stock (m^3/ha). From these values, total growing stock of FF could be estimated for each inventory year by using the total FF area. The mean growing stock of all FF that were identified before 2007 is 129.6 m^3/ha.
In each inventory year, the newly identified FF must be excluded from the FL-FL subcategory in that year, otherwise the volume stock changes, and thus removals of carbon, would be overestimated for the FL-FL subcategory. This is because neither the area, nor the carbon stocks of these FF are included in the FL-FL subcategory in the previous inventory year (as they are not known then). (Later, however, these FF become parts of the FL, because the definition of FL-FL starts over in each calendar year, and not in relation to a fixed point in time, which is the case in the land under Art. 3.4 Forest Management activity under the Kyoto Protocol when the beginning of the period of the definition of Forest Management, i.e. 1990, is fixed.)

A complete assessment of FF with respect to the area and carbon stock changes in 2009 is presented in Chapter 11.2.2. We note once again that both the area and the carbon stock changes in the FF are excluded from both FL-FL and L-FL in the inventory year when these FF are identified.

7.2.1. Forest Land remaining Forest Land (CRF sector 5.A.1)

Category description

The main characteristics of the FL-FL category can be found in Table 7.7. Note that data was recalculated in this year (see 7.2.6. section for details).

Table 7.7 *Emissions **(+)** and removals (-) in the FL-FL sub-category by gas and inventory year*

Inventory year	Area of subcompartments (ha)	CO_2 (Gg)	CH_4 (Gg)	CO (Gg)	N_2O (Gg)	NO_x (Gg)
1985	1,715,260	-1,409	1.38	12.05	0.0095	0.34
1986	1,727,263	-3,543	1.39	12.20	0.0096	0.35
1987	1,737,913	-3,939	1.34	11.75	0.0092	0.33
1988	1,747,732	-4,172	1.30	11.39	0.0089	0.32
1989	1,760,872	-2,913	1.30	11.37	0.0089	0.32
1990	1,774,548	-2,604	1.20	10.50	0.0082	0.30
1991	1,785,815	-2,867	1.17	10.22	0.0080	0.29
1992	1,800,111	-3,604	1.07	9.36	0.0074	0.27
1993	1,814,240	-5,291	0.94	8.26	0.0065	0.23
1994	1,824,982	-5,826	0.97	8.45	0.0066	0.24
1995	1,836,869	-5,846	1.01	8.83	0.0069	0.25
1996	1,847,447	-1,936	1.10	9.60	0.0075	0.27
1997	1,857,227	-2,186	1.12	9.78	0.0077	0.28
1998	1,865,328	-3,157	1.09	9.53	0.0075	0.27
1999	1,876,618	-1,522	0.98	8.55	0.0067	0.24
2000	1,889,854	-518	1.31	11.45	0.0090	0.33
2001	1,900,546	-1,935	1.18	10.35	0.0081	0.29
2002	1,912,927	-1,408	1.19	10.41	0.0082	0.30
2003	1,923,327	-3,533	1.17	10.27	0.0081	0.29
2004	1,936,722	-2,559	1.02	8.89	0.0070	0.25
2005	1,940,331	-4,649	1.62	14.16	0.0111	0.40
2006	1,953,956	-2,684	1.02	8.93	0.0070	0.25
2007	1,968,840	-2,930	1.46	12.74	0.0100	0.36
2008	1,978,854	-4,039	1.02	8.90	0.0070	0.25
2009	1,988,032	-3,077	1.00	8.76	0.0069	0.25

Methodological issues – CO_2 emissions and removals

As mentioned above, the general methodology to estimate emissions and removals in the forestry sector is based on the IPCC methodology (*GPG for LULUCF, IPCC 2006 Guidelines*). However, wherever it was possible, country specific data was used (Tier 2), and IPCC default values (Tier 1) were only used in a few cases. Emissions and removals leading to changes in the biomass and soil carbon pools are quantified, however, due to lack of data, only assumptions are applied with respect to other pools to comply with requirements to completeness.

Changes in carbon stocks in the biomass pools

Changes in carbon stocks in the biomass pools are estimated using the stock-change method. Due to the nature of the Hungarian forestry statistics, estimates of total volume of all forests in the country are available annually, thus, we can develop carbon stock change estimates for each inventory year.

This method has been applied in the national greenhouse gas inventory since 2006. Previously, the changes had been calculated, following the early advice of the IPCC 1996 Guidelines, using the “IPCC default method” (better termed as a process-based method or gain-loss method) where data on changes due to growth, harvests and disturbances was used. However, as it was noted several times in earlier NIRs, relatively high uncertainties are inherent in these data due to different reasons, therefore, we changed for the stock-change method (which is also consistent with what the IPCC 2006 Guidelines suggest in section 4.2.1.1. of Volume 4).

Fortunately, the National Forest Database contains also aggregate annual statistics on total growing stocks by species and age classes. These statistics are produced by a bottom-up approach, i.e. growing stocks of stands in the species and age class are added up. There are uncertainties around these statistics, too, however, they are regarded smaller, and systematic errors, i.e. most types of bias, are considerably reduced when consecutive growing stock values are deducted to obtain stock changes. We note, however, that since growing stocks and their changes incorporate the effects of all processes mentioned above, no particular inferences can be made separately for any of these processes.

Equation 2.8 of IPCC 2006 (which is a follow-up of equation 3.2.3 of the GPG for LULUCF, IPCC 2003) has been modified to adapt it to the Hungarian conditions. The following equation was used to estimate carbon stock changes of the biomass carbon pools:

$\Delta C_B = (C_{t2} – C_{t1}) / (t_2 – t_1)$ and

$C_t = [V_t * D] * (1 + R) * CF$

where

- ΔC_B = carbon stock changes of biomass (tonnes C)
- C_t = carbon stock at time t (tonnes C)
- V_t = growing stock at time t (m^3)
- D = wood density, tonnes m^{-3}
- R = root-to-shoot ratio (dimensionless)
- CF = carbon fraction of biomass (tonnes C tonnes biomass^{-1})
- t_1 and t_2 = two consecutive years.

We repeat here that neither the area or the growing stock (and thus carbon stock) of the forests that are found in the year t_2 are included in that year (because these F F are not known in year t_1). Therefore, when these forests become known to the inventory in year t_2 as FF (and not as afforestations), they do not become parts of the L-FL category, and both the

area as well as the volume (and thus carbon) stocks are excluded (i.e., subtracted) from the respective values for year t_2 to avoid that the carbon stocks, and not the carbon stock changes, enter the equation. In other words, $V_2 = V - V_{FF}$ where V is the total volume stock of all forests in the FL-FL category at time t_2., and V_{FF} is the total volume stock of forests that are found in year t_2.
(Note that the above procedure underestimates true volume stock changes, because it excludes the volume stock change of the FF as we do not know the growing stock of the stands of the FF one year before they enter the forest statistics. This approach inevitably results in a conservative approach to accounting because, although this land of young forests, whose mean age is around 32-37 years, is obviously a net sink, this sink cannot be accounted for.)
The application of the above equations is possible because, as it was mentioned above, the forest inventory is continuous to enable the preparation of forest management plans, which is achieved by surveying all individual stands once in every 10 years.
During the survey, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. The survey also includes mapping of the forest area. The survey methods applied in individual stands depend on species, age and site. More accurate methods are usually used for stands of higher volume stocks. In years between surveys, yield functions are used to update volume stocks. As a result, volume carbon stocks are available for each inventory year.
The forest inventory is conducted by the stuff of the Central Agricultural Office Forestry Directorate, which is about 300-400 forest engineers strong. The inventory data is stored by stand in a computerized database, i.e. the National Forest Database (NFD).
Tree volume in the forest inventory is calculated from measured diameter and height of sample trees using volume functions by Kiraly (1978), which are in turn based on volume tables by Sopp et al. (1974).

Concerning wood density, a new set of data was introduced in 2010. The current values (Table 7.8), which replace previous data that were oven-dry density values and which are used across all reporting years, are much detailed by species than before, and are basic wood densities based on a thorough revision of previous data reported in literature combined with re-measurements of wood densities for some species (Somogyi, 2008.)

***Table 7.8** Basic wood density values for the main species and species groups in Hungary as used in previous submissions (i.e. until 2010, “previous” values, Babos et al. 1979, and Kovács, 1979) and as used in this and subsequent submissions (“revised” values, Somogyi, 2008).*

Species or species group	Previous density (t/m^3)	Revised density (t/m^3)
Quercus robur	0.665	0.57
Quercus pertaea	0.665	0.61
Other quercus	0.665	0.55
Quercus cerris	0.77	0.64
Fagus silvatica	0.68	0.59
Carpinus betulus	0.79	0.58
Robinia pseudoacacia	0.74	0.59
Acer sp.	0.5925	0.52
Ulmus sp.	0.5925	0.58
Fraxinus sp.	0.5925	0.56
Other hard broadleaves	0.5925	0.50
Hybrid poplars	0.37	0.34
Indigenous poplars	0.395	0.36
Salix sp.	0.33	0.36

Species or species group	Previous density (t/m^3)	Revised density (t/m^3)
Alnus sp.	0.56	0.43
Tilia sp.	0.56	0.48
Other soft broadleaves	0.56	0.48
Pinus silvestris	0.53	0.42
Pinus nigra	0.53	0.47
Picea abies	0.53	0.39
Larix deciduas	0.53	0.49
Other conifers	0.53	0.37

Note that no biomass *expansion* factor is applied for the above-ground biomass, because all wood volume (m^3) values in Hungary are estimated, and expressed, as total volume of trees above ground including stem, all branches, twigs and bark, i.e. the volume of all aboveground parts of the trees (above stump, see above). To convert the total (above-ground) volume to above ground biomass, expansion is therefore not necessary, and only conversion is done to estimate biomass. However, the same conversion factor is used for the whole tree, i.e. for all of its parts, and since twigs and branches may have density that is different from that of wood, this method may introduce an unknown, but nevertheless slight bias.

With respect to the below-ground biomass, a general root-to-shoot ratio (R) is applied. Until a few years ago, carbon stock changes in the below-ground biomass carbon pool were not accounted for. Since 2006, below-ground biomass carbon stock changes have also been reported, however, in lack of proper data, IPCC default values are used in connection with expert judgement (Tier 1 methodology). Considering that the majority of the forests in Hungary are young, that the average volume stocks (calculated on the bases of the area of forest subcompartments) are 171 m^3 ha^{-1} (in 1990) and 186 m^3 ha^{-1} (in 2009), corresponding to an average aboveground biomass of 95 t ha^{-1} (in 1990) and 100 t ha^{-1} (in 2004), respectively, and that the IPCC default values have relatively high uncertainty, a conservative value of R of 0.25 is used for all species.
Concerning the carbon fraction of dry wood, the IPCC default values, i.e. 0.48 and 0.51 tonnes C tonnes biomass^{-1} are used for broadleaves and coniferous species, respectively.
The estimated net removals resulting from the above calculations are reported in Table 7.7 above.

Changes in the carbon stocks of the dead wood, litter, soils and harvested wood products pools

In Hungary, data has not been collected systematically, not even in the main ecosystem types, for dead wood, litter or soil. However, it seems justified to state that these pools continue to sequester carbon, rather than to lose carbon, in the medium-term.
To demonstrate that DOM is not an emitting pool, we present the results published in the European ICP-Forest, Forest Focus and Life+ programs on forest health (based on systematic sampling) showing the expectable constant accumulation of biomass of standing dead trees.

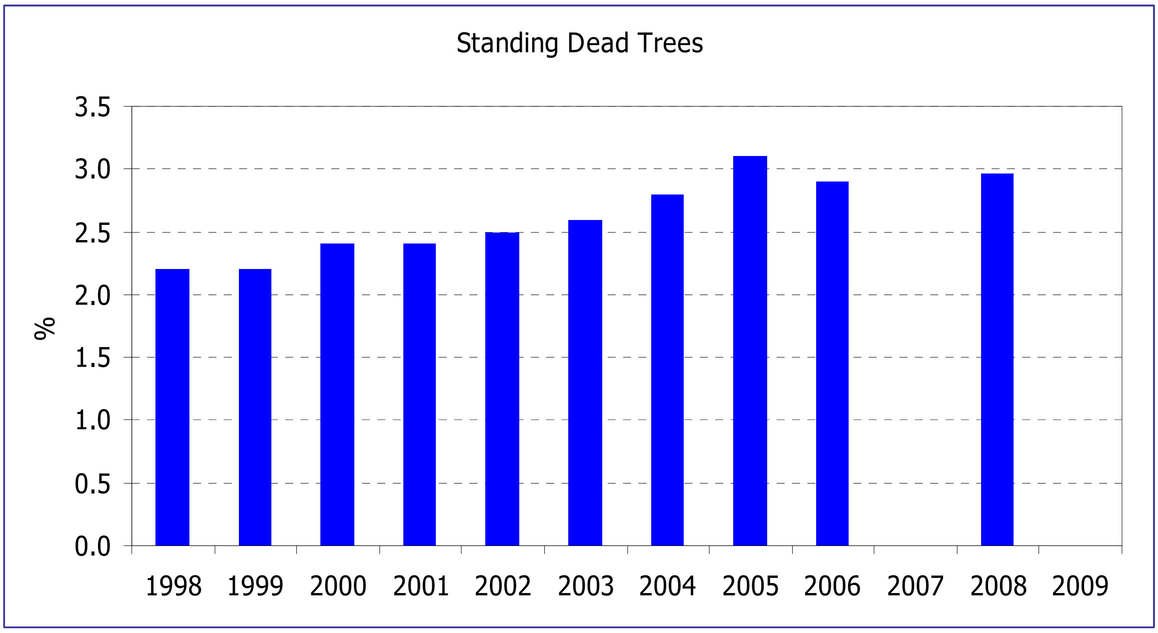


***Figure** 7.3 The amount of standing dead trees in Hungarian Forest (number of trees in the sample, %). Data source: IPC-Forest, Forest Focus and Life+ program, and Somogyi and Zamolodchikov, 2007. Note that no survey took place in 2007 and 2009.*

The slow but steady increase of the amount of standing dead trees, and in general that of the dead organic matter in the Hungarian forests, is mainly due to two reasons. One is the increased sustainability of managing existing forests, which means that less wood is harvested than what is grown. This effect can easily be seen from Figure 7.4, too, which shows the amount of estimated current annual increment in relation to harvest statistics. The difference of increment and harvests is large enough to claim not only sustained yield, which is also obvious from the growing trend of total volume stocks for the last two decades, but we can also safely assume that a lot of the uncut trees die due to the well known self-thinning rule in stands where density has become high, so the amount of deadwood keeps increasing, too. In the last decades, the close-to-nature forest management has been favoured in Hungary, and clearcuts were restricted, so we can assume the accumulation of both deadwood and litter in the Hungarian forests (which in turn also increases the carbon stocks of the soils). Additionally, no major disturbances or other processes are known that could result in substantial emissions from these pools. Therefore, although no quantitative estimates can be made on the increase, the Tier 1 assumption can safely be made that these pools are not sources, and their carbon stock changes are zero. (See also the demonstration in Chapter 11 that soils are not a source.)

The other reason of the increase of the dead organic matter in the forests is that about one-third of all forests are afforestations since 1930, and most of these forests are still in their intensive growing phase, which means that the dead organic matter pools have not saturated yet.

Concerning harvested wood products, changes in the carbon stocks in this pool are not reported. The reason for this, in addition to lack of proper data and proper methodology adopted, is the likely relatively small size of changes in this pool due to the fact that the amounts of carbon entering this pool (wood products from harvests) and exiting it (products ending their life cycle) are about the same. Note, however, that, indeed, and as reported in our Submission on Forest Management Reference Levels (SFMRL Hungary, 2011), small changes have been estimated in a study (Rüter, 2011) concerning the carbon stock changes of harvested wood products when applying a first-order decay function with default half-lives of two years for paper, 25 years for wood panels and 35 years for saw wood, which makes it not practicable to report them.

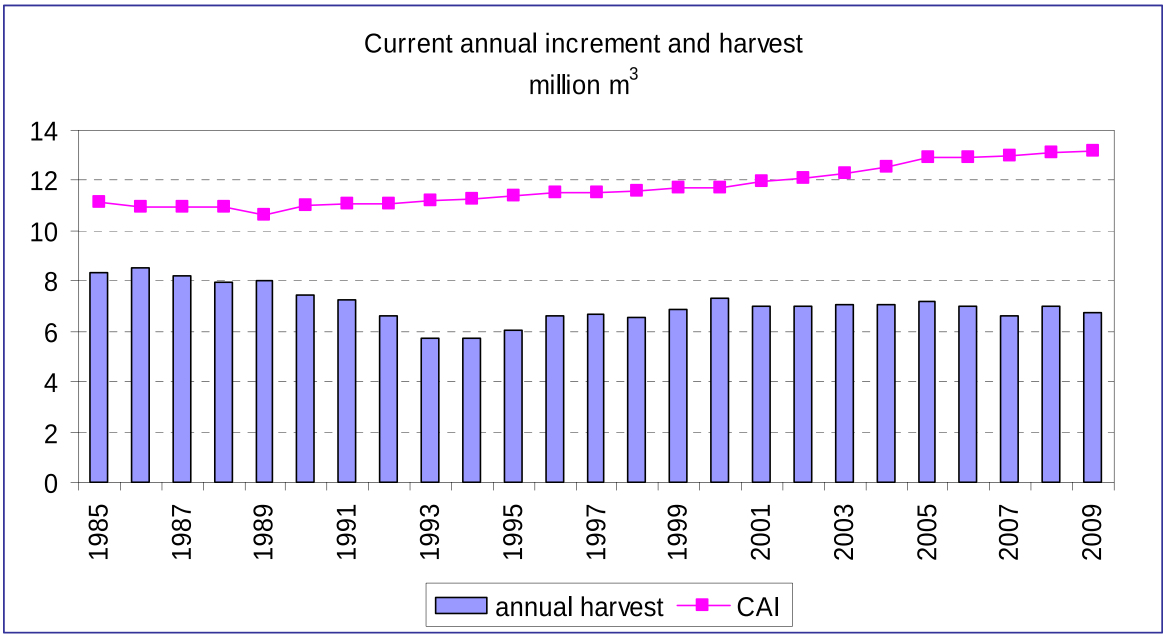


Figure 7.4 *Current annual increment (CAI) and annual harvest in Hungary in the last decades. Data source: National Forest Database.*

CO_2 emissions from liming

Emissions from liming cannot be calculated for forestry separately, as only country-wide statistics are available. All emissions from liming are therefore reported under Cropland subcategory.

Methodological issues – non-CO2 emissions

Estimated non-CO_2 emissions include those from burning of slash on-site and, for the last couple of years, from wildfires. Non-CO_2 emissions from the mentioned sources are not significant, and are only reported for the sake of completeness and that of time series consistency with previous years. Note that CO_2 emissions from these sources are accounted for in the biomass pool, because we apply the stock-change method. Theoretically, these emissions include carbon of CO and CH_4. However, these gases are nevertheless reported (complying with the methodology of the *GPG for LULUCF*) because of their high global warming potential, because the double counting of the carbon is negligible, and also in order to comply with the latest IPCC (2006) guidelines on reporting.

The estimation methodology of slash-burning is based on the method suggested by the *IPCC 1996 Guidelines*, as well as equation 3.2.19 of the *GPG for LULUCF (IPCC, 2003)*. Carbon released is estimated using harvest statistics (m^3 of wood removed from forest, see the graph above, from which the amount of slash was calculated using average values by species (see Table 7.9 below), which were developed in former country-wide specific project for statistical purposes). In addition, expert judgement was applied with respect to the fraction of slash burnt on site (0.2), and to the fraction that oxidized on site (0.9). Finally, the IPCC default value was used for the carbon fraction of harvested wood (0.5). The product of these values is first multiplied by default emission ratios by gas: 0.012 for CH_4, 0.06 for CO, 0.007 for N_2O, and 0.121 for NO_x. Then, for the nitrogen compounds, a general default value of 0.01 are applied to yield the total amount of nitrogen (N) released. Finally, the products obtained are multiplied by the appropriate molecular weight ratios, which are the following: 16/12 for CH_4, 28/12 for CO, 44/28 for N_2O, and 46/14 for NO_x.

Wildfires are very erratic in nature but not so significant phenomenon in Hungary. Beginning

1999, the Fire Department has provided data only on the number and area of forest wildfires, however, until 2006, these numbers are not deemed accurate, and the emissions based on these are only rough ones.

In 2006, Hungary joined to the European Forest Fire Information System (EFFIS, http://effis.jrc.it or http://www.jrc.cec.eu.int/), and a new database was established in the Twinning Project No. HU 2004/016-689.01.02. Thus, beginning 2007, the Fire Department locates the fires, surveys the affected area, and, subsequently, the Forest Authority identifies on site the affected forest sub compartments. The Forest Authority also collects data on how much percent of the growing stock of each forest sub compartment was burnt in the fire. (Only crown fires affect the biomass accounted in the GHG inventory, the surface- and ground fires only affect some of the understory vegetation, which is not reported anyway.) In this way, the activity data is double-checked, and the emissions can be accurately calculated based on the growing stock. The calculation applies the same factors as above, i.e., the fraction oxidized, carbon fraction of harvested wood, emission ratios by gas, N/C ratio, and molecular weight.

In the lack of other data, the amount of growing stock burnt in wildfires between 1999-2006 are calculated by the ratio of fire-affected area and the burned growing stock per unit area of wildfires of 2007-2008.

With the exclusion of some areas affected by forest fires that are subsequently considered as Deforestation (D), burnt areas remain under forest management by law, and the Forest Authority prescribes and inspects the reforestation/regeneration of these areas.

Table 7.9 *The amount of controlled burning and forest fires based on all available data.*

Reporting year	Harvested volume (m^3)	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m^3)
1985	8,345,562	999,660	NE	NE	NE
1986	8,500,991	1,012,554	NE	NE	NE
1987	8,193,145	975,181	NE	NE	NE
1988	7,960,397	945,002	NE	NE	NE
1989	8,031,779	941,890	NE	NE	NE
1990	7,415,162	867,795	NE	NE	NE
1991	7,255,202	846,173	NE	NE	NE
1992	6,588,569	775,646	NE	NE	NE
1993	5,723,745	683,589	NE	NE	NE
1994	5,717,468	697,710	NE	NE	NE
1995	6,049,151	728,540	NE	NE	NE
1996	6,603,733	791,934	NE	NE	NE
1997	6,713,101	807,859	NE	NE	NE
1998	6,578,931	786,791	NE	NE	NE
1999	6,900,612	825,188	229	756	3,000
2000	7,287,456	883,913	811	1,595	80,000
2001	7,010,979	843,752	419	1,223	57,000
2002	7,013,167	850,311	382	1,226	57,000
2003	7,053,960	857,268	375	1,054	49,000
2004	7,094,753	864,225	104	354	2,000
2005	7,167,426	885,614	150	3,530	170,000
2006	7,005,190	863,594	97	625	3,000
2007	6,609,099	812,238	284	3,471	160,660
2008	7,024,025	719,891	175	731	2,730

Reporting year	Harvested volume (m^3)	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m^3)
2009	6,773,537	700,299	329	696	7000

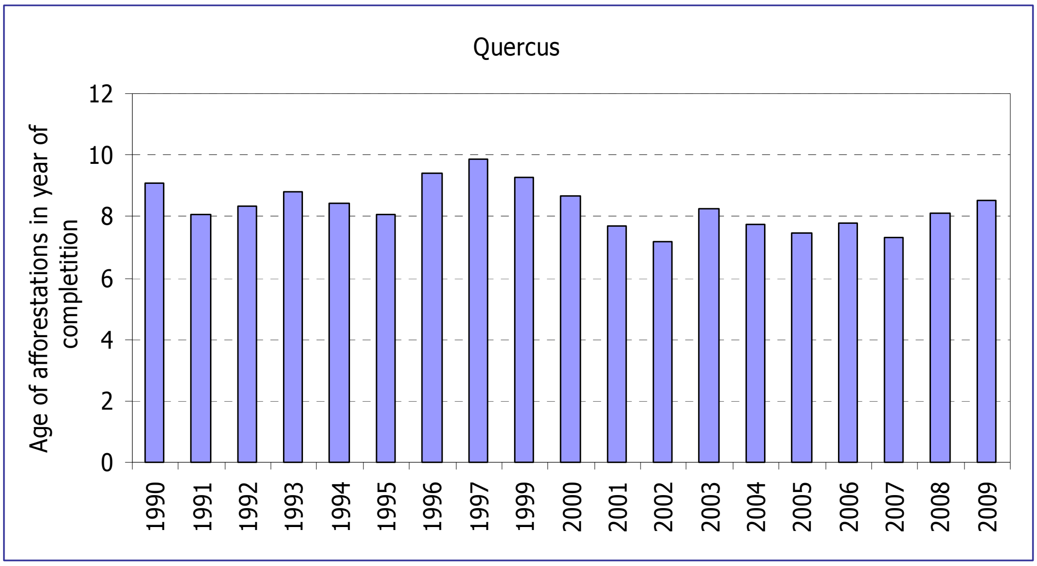
7.2.2. Land converted to Forest Land (CRF sector 5.A.2)

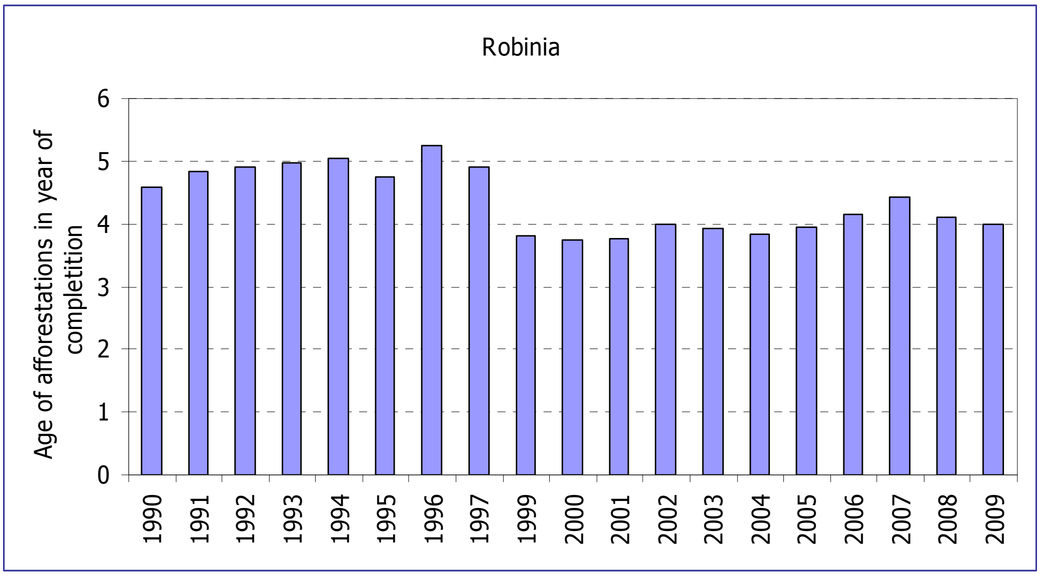
Category description

Carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) are reported in this category. As this sector represents a very minor contribution to greenhouse gas emissions and removals, only carbon stock changes in the biomass pools are accounted for.
(We note here that, according to recent estimates, converting land from croplands does not entail any emissions from soil, see Somogyi, 2005, Somogyi-Horváth, 2006a, Somogyi-Horváth, 2006b.
However, there are some indications that converting grassland to forest may lead to some emissions, see Horvath, B. 2006. Because most of the huge amount of marginal lands that are afforested are former croplands, and also because of biodiversity concerns, the overwhelming majority of conversions occur on abandoned croplands (81% of afforestation 1990-2009, from survey of CAO, Forestry Directorate), so no major emissions from soils are suspected during conversion.)

The estimated area of, and CO_2 emissions from, this category are summarized in Table 7.10 below.
Note that this category contains forests under afforestation until they are regarded as "forest land" in the National Forest Database. The time of the various stands in this category, i.e. the time that elapses from soil preparation until the stand is regarded as forest, changes by species, site, as well as climatic conditions and the appearance of pests/pathogens. This time can change between 2-3 years to 10+ years, the average being 8 years for slow growing species, 4-5 years for the faster growing Black Locust (Robinia pseudoacacia), and even less for poplars. Thus, we do not apply the default 20 year-long period as suggested by the GPG (IPCC 2003), rather, the more flexible approach by the IPCC 2006 Guidelines. This is because it is much more practicable for us to use available statistics that are based on some maturity characteristics of the afforestations rather than an inflexible 20-year time span.
Hungary has a long, very successful and internationally recognized tradition of afforestation. About the 30% of the current forests were planted since 1930. The afforestation efforts are still continuous, and mainly subsidy-driven. The subsidies are granted to each forest sub-compartment in three steps: (1) at initial planting, (2) in the second year, (3) in the year when the afforestation is deemed completed. The forest sub-compartments under afforestation are annually surveyed on site by the CAO Forestry Directorate, and the 3rd portion of the subsidy is only granted, if the juvenile stand is in good condition, has reached pre-defined height, and has overwhelmed the competing herbs and shrubs. This is the time when the Forest Authority declares the area as forest, and we account for this area in the FL-FL area. However, the year when the afforestation is declared completed differs by species and also by stand. The between-stand variation is mainly due to site conditions, weather, the local forest manager's efforts to complete the afforestation, and other local factors. The afforestated stands are recorded in the National Forest Database annually and can be tracked annually. This method of administration is based on individually stand-surveys and has been very successfully applied to ensure the successful completion of the afforestations.
One consequence of this method is, however, that the category of land in the conversion phase always includes areas of various species that have just been afforested (0-1 year), that have been tended (1, 2 or more years), and also that are just before their completion and formal reclassification to the FL-FL category (i.e., stands of several years, depending on

species, awaiting for being “completed”).
The average age of the various species in the afforestations is rather different, and, in any given inventory year, fluctuates over time (Figure 7.5). Also, the total area of sub-compartments in this category also keeps changing, as it may happen in any year that not a single ha is afforested with a certain species, but a lot in the following year, which depends on land owner’s choice to do afforestations. As a consequence of all of the above, the amount and type of land included in this category, and also the carbon stock changes of this category, is not so much a result of natural processes, rather, an artifact of the sum of incoming and outgoing sub-compartments.





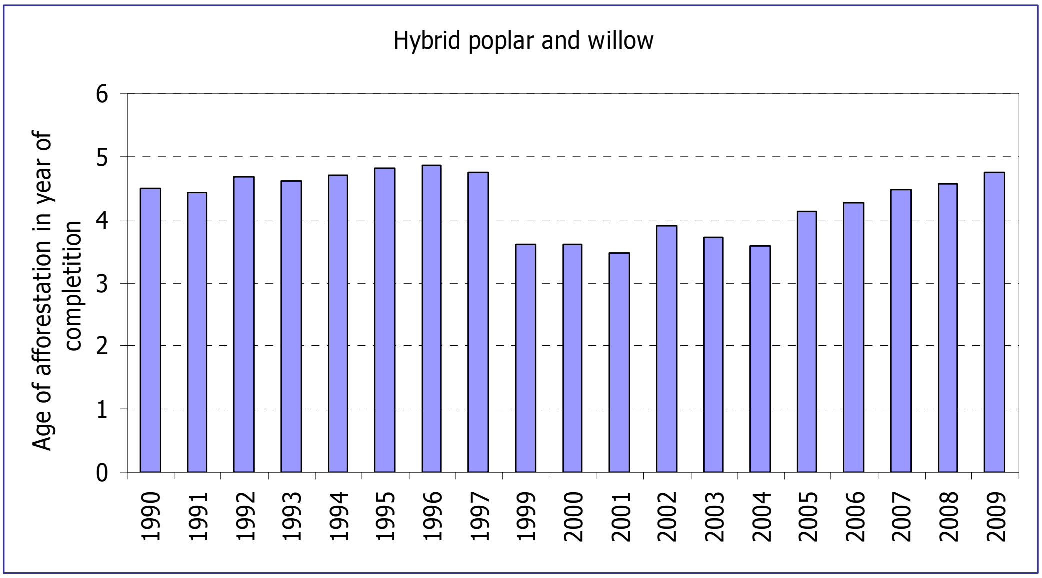


Figure 7.5 *Average age of Quercus, Robinia, and Poplar and Willow afforestations in the year of completition (for explanation, see text).*

In 2010, the emissions and removals of L-FL were completely remodeled based on the official annual reports between 1989 and 2008 of the CAO Forestry Directorate. These reports contain area- and species composition data of the afforestations in 3 distinct categories: (1) the afforestations in the year of initial planting, (2) afforestations „under construction", between category 1 and 3, and (3) afforestations in the year of completing (actually transforming them into FL-FL). The growing stock of the L-FL area is registered in the NFD, and is estimated by a specific, although simplified, yield model.

Table 7.10 *The area, as well as CO_2 emissions and removals on land converted to forest*

Inventory year	Area (ha)	CO_2 (Gg)
1985	40,380	21
1986	38,570	45
1987	38,778	9
1988	39,875	-7
1989	40,563	-3
1990	39,354	24
1991	39,589	-29
1992	38,228	-7
1993	32,098	66
1994	27,159	90
1995	24,552	48
1996	24,299	38
1997	26,342	11
1998	28,634	6
1999	30,894	7
2000	31,316	13
2001	36,398	-51

Inventory year	Area (ha)	CO_2 (Gg)
2002	42,253	-65
2003	44,246	-53
2004	44,180	-58
2005	42,949	-71
2006	44,516	-49
2007	50,354	-99
2008	51,975	-106
2009	51,314	-139

Methodological issues – CO_2 emissions and removals

Concerning biomass, methodologies used in this category are the same as used in the forest land remaining forest land category.
We note here again that, due to the inherent nature of the stock change method, because different lands move into and out from this category, and because the time that the various land areas are accounted for in this category significantly varies by species and site, the reported carbon stock changes are not due to, and cannot be interpreted as, only driven by natural processes like tree growth etc., rather, they are mostly artifacts as far as annual values are concerned. Therefore, implied emission factors and other indices, which are in other cases useful for error checking or verification, cannot be interpreted for any single year, rather, only statistics for longer periods can be regarded as meaningful. The long-term average carbon stock change is, however, zero because this is not a category that inherently grows, rather, which only temporarily contains incoming, and then outgoing, sub-compartments.
With respect to deadwood and litter, the assumption is made that the stock change is zero, and it is thus not reported. This is a justified and conservative assumption, because both the litter and deadwood pools are zero before the conversion, and usually increase after the conversion.

7.2.3. Forest Land converted to other land uses (CRF sector 5.B.2.1, 5.C.2.1, 5.D.2.1)

Forest land in Hungary is rarely converted to other land uses, and the conversions only include conversions to cropland, grassland and settlements. Conversions from forest land to other land used types are generally prohibited by the Forest Act, and can take place only after the Forest Authorities give their consent. The area of conversions can thus be surveyed, is estimated using the land conversion database of the Forest Authorities. However, these statistics are only available since 1985, and the average of the period 1985-1989 is used for the previous years for which estimates are also needed to run up the estimation of emissions from soils.

Methodological issues – CO_2 emissions and removals

CO_2 emissions and removals are estimated for the biomass and for the soil pools. For the other pools, we assume that carbon stock changes are close to zero, i.e. insignificant, and it is not practicable to estimate them.

For biomass, we follow the same methodology that is detailed in the FL-FL category. Note that this is different from earlier years (2010 and before) when we did not explicitly differentiate the FL converted to other land uses category, and when the carbon stock change estimate for the FL-FL category included that of deforestations. Beginning 2010, we report emissions from deforestations. In the carbon stock change calculation, we assume that the biomass carbon stock is equal to zero after the conversion, so the total carbon stock of the deforested land right before the deforestation is completely emitted.

For soil, we follow the default method of IPCC (2003, 2006). In this method, a 20-year-long period is assumed during which the carbon stock of the forest soil, which for this estimation is deemed to be in equilibrium before the conversion, reaches a new equilibrium level after the conversion. Thus, for each conversion type (i.e. FL to CL, FL to GL, and FL to SE), the area is needed for each inventory year. To estimate the annual carbon stock change of a converted land for an inventory year, its area must be multiplied by 1/20th of the difference between the equilibrium soil carbon stock of the land use type before the conversion (i.e., FL) and after the conversion (i.e., CL, GL and SE). For each piece of land converted, the same amount of carbon stock changes are accounted for 20 consecutive years. Thus, for any conversion type and for any inventory year, the total annual carbon stock changes of the newly deforested areas, as well as those of the previous 1-19 years must be added up. Finally, carbon stock changes for the conversion types must also be added up.

For the estimation of carbon stock changes by conversion type, we identified sub-categories by climate, soil, management and input type (see section 7.3.2). Based on a country-wide classification, this resulted in the distribution of land within conversion types. All deforested land was then classified into conversion types, thus, we got areas by conversion type and the within-conversion type categories. Finally, default IPCC soil reference and other factors were used to estimate the difference of carbon stock change between FL and land use type after conversions.

The areas identified, and the resulting CO_2 emissions are included in Table 7.11.

Table 7.11 *The area, as well as CO_2 emissions and removals from soils on land converted from forest to other land uses.*

Inventory year	FL converted to CL		FL converted to S		FL converted to GL		All conversions from FL to other land use	
	Area (ha)	CO_2 emissions (Gg)	Area (ha)	CO_2 emissions (Gg)	Area (ha)	CO_2 emissions (Gg)	Area (ha)	CO_2 emissions (Gg)
1985	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1986	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1987	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1988	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1989	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1990	180.0	3.396	392.6	7.066	40.3	0	612.9	10.462
1991	59.9	3.336	167.0	6.996	12.9	0	239.8	10.332
1992	44.4	3.250	71.8	6.772	9.4	0	125.6	10.023
1993	12.7	3.109	233.1	6.809	82.7	0	328.6	9.918
1994	28.4	2.996	162.5	6.732	27.3	0	218.2	9.727
1995	53.2	2.924	244.1	6.786	60.5	0	357.8	9.710
1996	78.7	2.897	188.1	6.750	79.0	0	345.9	9.647
1997	192.1	3.064	239.6	6.797	90.3	0	522.0	9.861
1998	88.9	3.054	271.4	6.895	41.7	0	402.0	9.948
1999	26.8	2.937	277.9	7.003	90.7	0	395.4	9.940
2000	67.8	2.891	594.9	7.621	56.4	0	719.1	10.512
2001	61.4	2.833	358.6	7.860	100.9	0	520.9	10.693
2002	108.9	2.857	439.5	8.228	89.2	0	637.5	11.085
2003	25.7	2.738	523.4	8.732	44.1	0	593.3	11.470
2004	74.2	2.702	750.5	9.600	119.1	0	943.8	12.303
2005	71.2	2.661	313.2	9.765	26.7	0	411.1	12.427
2006	44.4	2.574	443.4	10.140	20.8	0	508.6	12.715
2007	16.4	2.440	192.5	10.111	36.6	0	245.5	12.551
2008	97.0	2.443	162.0	10.030	35.0	0	293.8	12.473
2009	56.2	2.374	296.8	10.168	102.7	0	455.0	12.542

Methodological issues – Non-CO_2 emissions and removals

As deforestations rarely occur in the country, it is a close-to-zero probability that wildfires affect these areas. In the last years, no wildfires occurred on land that later (in the same year) was converted to other land use. Therefore, emissions from wildfire are reported as not occurring.

On the other hand, controlled burning (burning of slash) occurs on this land. The methodology to estimate emissions from this source is the same as described in section 7.2.3.

N_2O emissions from disturbance associated with land-use conversion to cropland also occur on this land. The basis for the estimation of these emissions is the assessment of the CO_2 emissions from soils as presented above. Using these CO2 emissions for cropland, we applied Equations 3.3.14 and 3.3.15 of the GPG (IPCC, 2003). As no country specific emission factors exist for this tiny source of emissions, we applied the IPCC default factors for the estimation.

7.2.4. Category-specific uncertainties and time-series consistency

The main objective of this uncertainty analysis, complying with that of the IPCC Guidelines, is to identify possible major sources of errors, and to indicate where efforts on development should concentrate in future inventories. We note here that uncertainties were assessed for the first time for the 2000 inventory. In 2003, Hungary applied quantitative sensitivity analysis to her LULUCF GHG balance, based on expert judgment.

Information on uncertainties includes, among others, information on completeness, accuracy, and non-quantifiable elements. Concerning *completeness*, some minor emissions and removals could not be estimated, because of the reasons provided above, however, it is highly probable that their exclusion only results in conservative estimation, i.e. overestimation of net emissions, and underestimation of net removals.

With respect to *accuracy*, the reported estimated values are generally accurate as far as practicable. An example for this is the revised basic density values. Where uncertainty seems to be high, and for *non-quantifiable factors*, the principle of conservativeness is applied. Conservative estimates are used for volume stocks and their change. Conservative assumptions are used for the root-to-shoot ratio, and in the case of carbon stock changes in soils, litter and deadwood.

It is probable that total forest area is underestimated, which is shown by the fact that the forest inventory still identifies new forest areas each year. One reason for that can be afforestations that are done by land owners from your own budget (i.e. not using EU subsidy, which is the main source of afforestations). It is also probable that both volume stocks, and therefore, volume stock changes are underestimated. The basis for this assessment is a sample-based inventory which, currently as unofficial statistics, indicates higher volume stocks and higher volume increment. Finally, wood harvests also seem to be underestimated due to illegal cuttings, which, according to some expert judgements, may account for some 250,000 m^3 of harvest that is additional to the annual official figure of around 7 million m^3 (this figure being variable from year to year). Considering the underestimation of volume stock and wood harvests in combination, volume stock changes are most probably underestimated.

As mentioned before, accuracy was improved e.g. by introducing new, more realistic, country-specific based wood density values.

Finally, accuracy cannot always be quantified, partly because the error distributions are unknown due to lack of measured data, partly because calculation errors, or because assumptions cannot be quantified. However, calculation errors are highly unlikely, due to the double-checking of the data processing.

For carbon stock changes in biomass, the system of calculating allows for the use of even simpler sensitivity analysis than before. This is especially true if only the major sources of CO_2 emissions and removals are considered, which the bulk of all emissions and removals are. The reason for this is that the equation inherent in the calculation is simple: only volume stock changes, wood density, root-to-shoot ratio, and carbon fraction factors are involved. A detailed uncertainty analysis for the biomass carbon stock changes is presented in Chapter 11, and below a few additional considerations are made.

With respect to the uncertainty of the *annual* CO_2 emissions, actual values may deviate more from estimated values, as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests.

We note again that a comprehensive uncertainty estimation is presented in Section 11.3.1.5 to analyse the possible effects of the uncertainties in current annual increment, basic wood density and root-to-shoot ratio on the carbon stock change estimates.

It can be concluded that, with regard to carbon stock change estimation, many sources of error have been removed earlier by switching from the process-based method to the stock-change method. Thus, it is expected that current estimates better reflect emissions and

removals associated with forest land than previous estimates.
With regard to non-CO_2 emissions, the estimation is accurate as far as practicable for the years for which we have data. Data collection has improved a lot for most recent years, the estimate for 2008 being the most accurate one.
The probability of errors in the various data is of course different. It seems that the activity data (i.e., carbon stock changes) are most important for the ***trend*** uncertainties, because all other factors are consistently applied throughout all inventory years. Although no information is available on the accuracy of the volume stocks, it is likely that it is below 10%, and could only be improved with unduly high additional investments.
Finally, both methods and data are applied consistently throughout the entire reporting period. This results in a consistent time series of the GHG information.
Please refer to Section 11.3.1.5 for further details.

7.2.5. Category-specific QA/QC and verification

Calculations are generally based on the activity data taken from the National Forest Database, and the databases of the Forest Authorities on afforestations and deforestations. These databases are the most accurate ones in the country on the forests. The first complete and country-wide inventory was accomplished in 1976 and has been applying computer-based informatics since the early ’80-s. The database is updated annually, field data is collected by the stuff of the Central Agricultural Office Forestry Directorate (involving 300-400 forest-engineers), and the data is checked by many people at subsequent procedures from field assessment to data processing. The constant development of field methods and informatics, improvement of checks, and increasing requirements on quality of work resulted in growing accuracy of the Database in recent years.
This year the GHG is completed by the CAO Forestry Directorate (formal National Forest Service), i.e. the institute that runs the National Forest Database and other mentioned databases.
Apart from double-checking of the data processing and correct application of IPCC assumptions and methodologies, QA/QC was performed at the national level by the Hungarian Forest Research Institute. The separation of the two roles (i.e., to prepare and to check the GHG inventory) has also improved the data quality. Final checks and integration of the data into the GHG inventory was performed by the Hungarian Met Office.
Data verification was, and continuously is, conducted concerning activity data (see the comparison of volume stock changes with trends of wood volume increment and harvest, see also previous NIRs of Hungary). The applicability of background data and correctness of the arithmetics used were double-checked. All background information is archived by the inventory agency. Thus, the correctness of the estimation methodology is in principle verifiable.

7.2.6. Category-specific recalculations

Removals of the FL-FL was recalculated reducing them by the removals of the so called "Found Forest" (i.e., forest not identified in 1990, but identified in the inventory year). See chapter 11.2 and Figure 11.2 for details.

Emissions from wildfires of years 1985-1998 were estimated based on the mean share of wildfires from the total amount of emissions from burning (controlled burning + wildfires) between 1999 and 2009. There is no activity data available for wildfires for 1985-1998, and the interannual variability of wildfires is pretty high, but the estimation using the above mean may be adequate for the mean of the 14 year-long period.

Recalculation since the last inventory year took place this year as a result of new data with respect to the re-estimation of the distribution of land use type in the D category between 2005-2009: new area of FL to CL, FL to SE and FL to GL is estimated based on relevant developments in the NFD. We identified an attribute of deforestations registered in the NFD that can be used to estimate the extent of the probable future soil-disturbance in these categories. (The following sub-categories were developed: areas of recurring annual disturbances, single disturbance and no disturbance.)

A small calculation mistake was also corrected in the D soil emissions.

The net removals (NR) of FL-FL were recalculated between 1985-2008. The calculation of net removals is based on the annual growing stock data of total forest under forest management plans (Total Forest). The growing stock data regards the end-of-the-year date (i.e., 31 December) each year. The equation applied is the following:

[NR of Total Forest] = [NR of FL-FL] + [NR of L-FL] + [C stock of new FF] – [NR of D].

In the last submissions we didn't take into consideration the net removals of D, and it was corrected in this submission.

A small numerical mistake was corrected in the reference-level data of L-FL area, both in area and removal (reference levels are calculated by the average of the years 1985-87, and the data of year 1987 counted twice in the average).

Carbon stock changes of DOM (deadwood & litter) from D are now estimated. See chapter 11.3.1.2 for details.

7.2.7. Category-specific planned improvements

Further verification of both the activity data, as well as the factors applied seems still necessary, and is planned in the future.

Refinement of definitions of DOM pools: exact distinction of litter and accumulated smaller branches on the ground is needed and is planned to be made.
Accumulation models for deadwood in AR areas, based on chronisequences of different forest types, are also planned to be developed.

7.3. CROPLAND (CRF sector 5.B)

7.3.1. Description of category

Though a significant decrease of the area of croplands was characteristic for the last four decades - roughly 800,000 hectares were abandoned or transferred to another category of land use – cropland still represents the main land use category in Hungary with its 56% proportion of the total territory of the country (Figure 7.1). All the plough-lands with annual crops and orchards and vineyards with perennial woody crops and kitchen gardens are classified here. The set-aside croplands are also reported in this category. The areas of Cropland are shown in Table 7.12.

***Table 7.12** Cropland areas 1985-2009 (1,000 ha)*

Year	Area [1,000 ha]				
	Annual Cropland[1]	Perennial Cropland		Set-Aside Cropland	Total Cropland
		Orchard	Vineyard		
1985	5,036	104	154	184	5,477
BY	5,042	100	149	180	5,470
1986	5,044	99	147	178	5,468
1987	5,048	97	145	177	5,466
1988	5,050	95	142	177	5,464
1989	5,052	94	140	173	5,460
1990	5,054	95	139	169	5,456
1991	5,009	95	134	192	5,430
1992	4,963	96	130	214	5,404
1993	4,918	96	126	257	5,397
1994	4,873	96	122	302	5,393
1995	4,828	96	118	344	5,386
1996	4,782	96	114	385	5,378
1997	4,737	97	109	425	5,368
1998	4,692	97	105	466	5,360
1999	4,647	97	101	505	5,349
2000	4,601	97	97	543	5,338
2001	4,601	98	93	532	5,324
2002	4,601	97	92	517	5,307
2003	4,600	97	91	507	5,295
2004	4,600	96	90	496	5,282
2005	4,600	96	88	495	5,279
2006	4,599	95	87	482	5,264
2007	4,599	95	86	466	5,246
2008	4,598	95	85	457	5,235
2009	4,598	94	84	450	5,226

[1]Kitchen gardens included.

The area of Cropland category is based on the HCSO's annual land-use statistics, revised by the HCSO's and the HMS's experts to avoid inconsistencies (Annex A3.4).
The CO_2 removals and emissions from living biomass, dead organic matter, mineral soils and agricultural lime application are reported under this category. (Organic soils are not under cultivation in Hungary.) N_2O emissions from disturbances associated with land-use

conversion to Cropland are also to be reported in CRF table 5(III). CH_4 and N_2O Emissions from Wildfires were previously omitted due to lack of activity data and are now included for the whole time-series. The net CO_2 emission from Cropland was 258 Gg in 2009, the CH_4 and N_2O and emission were 0.06 and 0.09 Gg respectively. Figure 7.6 shows the trends in emissions and removals from Croplands over the period 1985-2009 (N_2O emissions from land disturbance included in mineral soils).

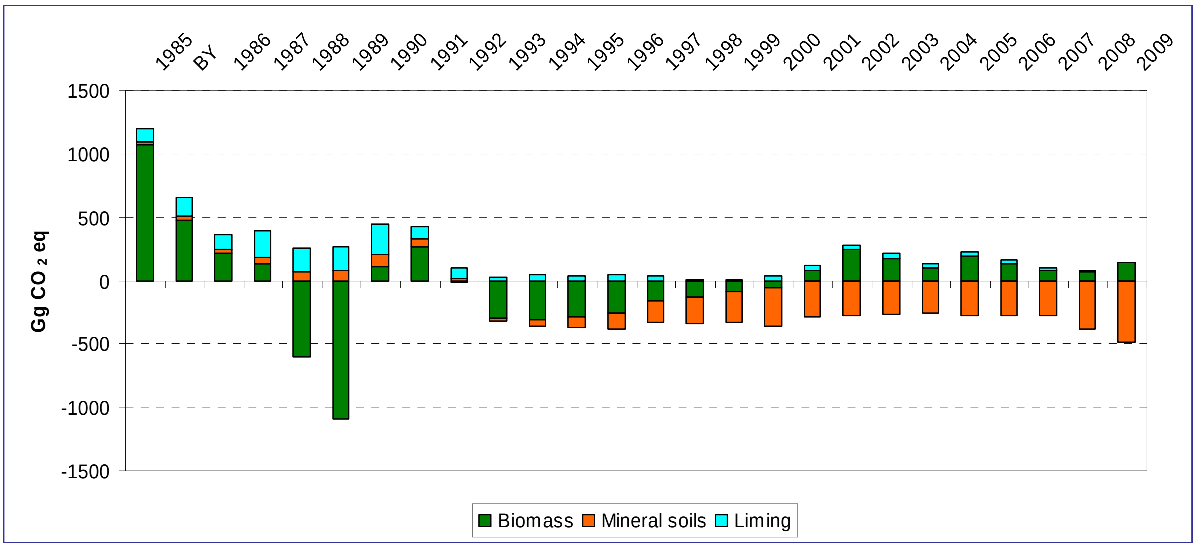


Figure 7.6 *Emissions/Removals from 5.B category Cropland 1985-2009*

7.3.2. Methodological issues

Cropland remaining Cropland

This category comprises emissions and removals from the change of management practices (including the effects of the abandonment) on croplands.

<u>Carbon stock change in living biomass</u>

In accordance with the GPG for LULUCF (IPCC, 2003) the change in biomass is only estimated for perennial woody crops, because there is no net accumulation of biomass of annual crops.

In 2009 Cropland living woody biomass was a source of 253 Gg CO_2 due to vineyard removals. The living woody biomass comprises the orchards and vineyards in Hungary (see Table 7.12). There is a permanent vineyard abandonment system in the EU; therefore vineyard removal is subsidized in Hungary similarly to other EU member states.

Vineyards were a source of 204 Gg CO_2, while orchards were a source of 49 tones carbon in 2009, because both of the area decreased in 2009.

The trend in emission from Cropland woody biomass is changeable over the time series as shown in Figure 7.7.

It is important to note that the removal and plantation due to land conversion cannot be distinguished from the replantation of vineyard and orchard areas from the data available, therefore the estimated emissions/ removals contain the effect of land-use conversion as well. All carbon stock changes in living woody biomass are reported in 5.B.1 Cropland remaining Cropland category.

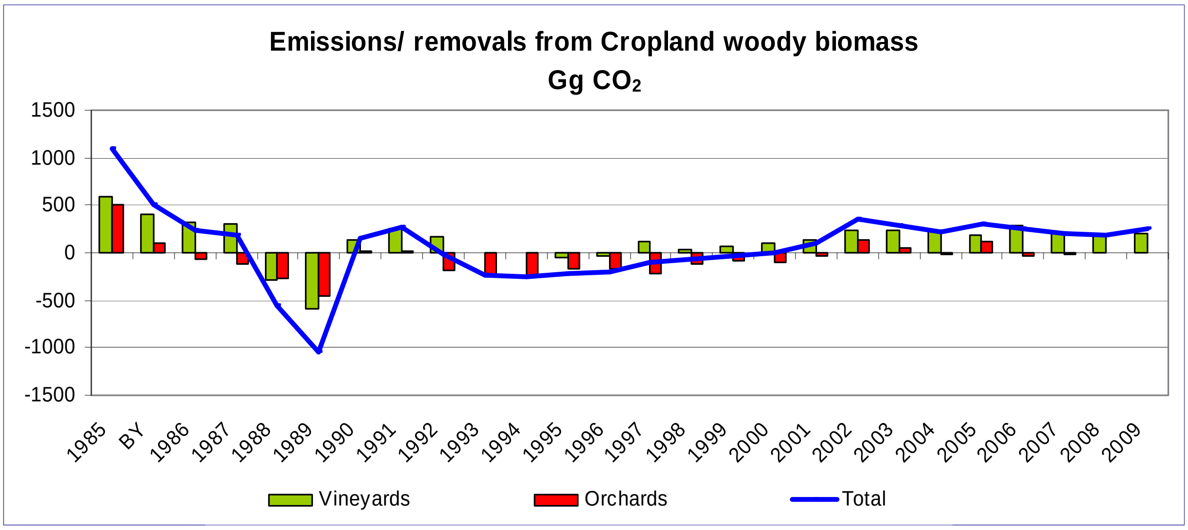


Figure 7.7 *Trends in emissions/removals from Cropland living (woody) biomass 1985-2009*

Choice of method

Carbon stored in the biomass of croplands was calculated taking the perennial woody vegetation (in Hungary including orchards and vineyards) into consideration. The carbon stock change in cropland biomass (ΔCC_{LB}) was estimated from the annual rates of biomass gain and loss provided by the Tier 1 methodology of GPG for LULUCF (IPCC, 2003). Similarly to the Equation 3.2.2 of the GPG for LULUCF (IPCC, 2003) the following formulas were applied:

$$\Delta CC_{LB} = \Delta C_G - \Delta C_L$$

Where:
ΔCC_{LB}=annual change in carbon stocks in living biomass on Cropland
ΔC_G= annual increase in carbon stocks due to biomass growth, tones C yr^{-1}
ΔC_L= annual decrease in carbon stocks due to biomass loss, tones C yr^{-1}

$$\Delta C_G = A_G \cdot G$$

$$\Delta C_L = A_L \cdot L$$

Where:
A_G= area of perennial woody cropland (orchard and vineyard in Hungary)
G= IPCC default value for perennial crops carbon accumulation rate is 2.1 t C ha^{-1} yr^{-1}
A_L= area of cropland on which perennial woody crops (orchard and vineyard) are removed
L= IPCC default value for perennial crops carbon loss, 63 t C ha^{-1} yr^{-1}

Choice of activity data

Activity data to estimate land areas (A_G, A_L) of growing stock and removals in perennial woody crops are derived from the statistics of the HCSO. The HCSO's records the orchard and vineyards area divided by legal forms (private farms and agricultural enterprises), but removals are reported only for agricultural enterprises. Therefore a process was elaborated to estimate the missing removal statistics for private farms which is shown in Annex A3.4. The methodology for the estimation of the missing activity data is considered to provide a relatively conservative approach to the calculation of emissions and removals.

Uncertainty assessment

Uncertainty of the HCSO's Vineyard and Orchard area data for the period from 2002 to 2005 is 5.8 percent and 6.1 percent respectively. (Uncertainty assessments for area data for other periods are not available.) The default uncertainty level of biomass stock factors is ±75% according to Tier 1 method. Therefore an uncertainty of ±53.4 % can be assumed for the combined uncertainty of the carbon stock change in living woody biomass.

Carbon stock change in soils

To estimate the change of carbon stock in soils, the change of the view in soil cultivation has to be taken into consideration. As soil - besides the climate and weather - is one of the main factors of production, which basically determines the quality and economical conditions of production, the knowledge of the effects of plant production on soil is very important. Among the land use practices the soil cultivation has the most radical effects on soil properties. The need for environmental friendly and energy saving soil tillage systems is increasing as the consequences of improper soil cultivation practice that characterized the last decades are manifested in unfavourable soil properties (Birkás, 2002, Birkás et al., 2007). In accordance with the combat against the damages (soil degradation) due to the improper soil use, the conventional soil cultivation methods are prospectively replaced by conservation tillage, including different versions of reduced till, mulch-till, crop residue management etc. (Forgács et al., 2005, Zsembeli, 2001). These new soil tillage methods aim the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter, hence affect soil C stocks in croplands considerably. All over the world several soil cultivation methods were studied in order to investigate their effects on the soil state and properties including the water balance and C-cycle. Though In Hungary there are no extensive measured data yet, some results have been already achieved concerning the effect of reduced tillage systems on the CO_2-emission from the soil providing several valuable information in the respect of soil utilization (Gyuricza et al., 2005; Tóth and Koós, 2006; Zsembeli et al, 2005, 2006; Zsembeli and Kovács, 2007).

According to the summary Equation 3.3.2 of GPG for LULUCF (IPCC, 2003), the change in organic carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in cropland remaining cropland, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in the Cropland category in Hungary in 2009 was 139.4-3.1=136.3Gg C.

Mineral soils

In 2009 mineral soils in category 5.B.1 Cropland remaining Cropland was a sink of 206.4 GgC. Over the period 1965-1998 the carbon stock of cropland is considered to be static, because there was no significant change in management practices. The full tillage of croplands was the only applied cultivation system until the end of 1990ies, but from 1998 the conventional soil cultivation was prospectively replaced by conservation tillage methods. The new, conservation tillage methods resulted in a miner increase in the carbon stock of croplands in Hungary from 1998.

Choice of method

For calculation of carbon stock change in mineral soils the IPCC Tier 1 method the Equation 3.3.4. B of the GPG for LULUCF (IPCC, 2003) was used as follows:

$$\Delta C_{CCMineral}=(SOC_0-SOC_{0-T})\cdot A/T$$
$$SOC=(\sum_{csi}(A_{csi}\cdot SOC_{ref}\cdot F_{LU}\cdot F_{MG}\cdot F_I))/\sum_{csi}A_{csi}$$

Where :
$\Delta C_{CCMineral}$ =annual change in carbon stock in mineral soils
SOC_0= *average* soil organic carbon stock in the inventory year
SOC_{0-T}= *average* soil organic carbon stock T years prior to the inventory
A= land area
T= inventory time period (the default 20 years was applied)
SOC_{ref}= the reference soil carbon stock
F_{LU}= stock change factor for land use or land-use change type
F_{MG}= stock change factor for management regime
F_I= stock change factor for input
c represents the climate zones, *s* the soil types and *i* the set of major management system.

In Hungary the soil organic carbon stock can be estimated aggregately for the different land-use types, therefore the average carbon stocks were used for the calculation. The average carbon stock for the different land-use categories were determined from the categorization by climate zones, soil types and management practices.
The categorization of croplands is partly based on expert judgement due to the lack of sufficient statistics mainly about the management and input of the recent Hungarian land use practice. Nevertheless the input factors can be judged well on the base of the actual composition of annual crops, while the change in the management practice can be followed by knowing the number of the tools and machines that are used in reduced tillage. The methodology of these judgements is detailed in the *Choice of activity data* paragraph below.
The estimated average carbon stocks for Cropland for the period 1965-2009 are shown in Table A3-8 and A3-9 of Annex A3.4. (Although the land-use transition is taken into account due to lack of information before 1985. The average carbon stocks are estimated from 1965.)

Choice of activity data

In order to gain relevant activity data, the area of croplands was stratified by soil type, climate, management and input. For the identification of the spatial extension and distribution of each sub-category the area data from the HCSO were harmonized with the data originating from the CORINE Land Cover Database reference to 2000.
The area data stratified by climate, soil type and management practices are provided in Table A3-8 and A3-9 of Annex A3.4.

Soil type

The soil types were determined on the base of AGROTOPO (digital soil map of Hungary) data base and were harmonized with the land use types of CLC to determine the rate of land use types on different soil types (GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences). The Hungarian national soil classification system classifies soils by genetic types, and these types are not comparable with the types identified by the WRB or the USDA systems. Therefore there was a project, titled “Improvement and international correlation of the Hungarian soil classification system”, founded by the Hungarian Scientific Research Fund, managed by Erika Michéli. This study was the base of the classification of the soils of Hungary into the soil type groups needed for the calculations. As a result of the classification the croplands in Hungary occupied four soil types from among the types that are determined in the GPG for LULUCF (IPCC, 2003) with following proportions of the total land in 2009 (Table 7.13).

Table 7.13 *Classification of the croplands in Hungary by soil type in proportion to the total land*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	77.22
Low Activity Clay Mineral	2.16
Sandy	5.17
Aquic	15.45

As the proportions show, high activity clay mineral soils are dominant. Among the soils utilized as croplands chernozems, brown forest soils represent this group. Salt affected soils, which are also characteristic to Hungary, also belong to this group, but they are also used as grasslands, mainly depending on the extent of salinization.

Climate

The climatic classing, the determination of the spatial distribution of climate zones was made by the Hungarian Meteorological Service. Two categories were determined: namely Cold Temperate Dry (CTED), where the mean annual temperature (MAT) is just below 10℃ and the annual precipitation is less than the evapotranspiration, and Warm Temperate Dry (WTED), where the mean annual temperature (MAT) is above 10℃ and the annual precipitation is less than the evapotranspiration. After determining the climate zones, they were harmonised with the soil classing: the four soil types were classed into the two climate categories (made by the GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences) according to their spatial distribution in Hungary. As a result, the proportions indicated in the following table were gained (Table 7.14)

Table 7.14 *Classification of the croplands in Hungary by climate in proportion to the total land*

Soil Type Category	Proportions by Climate Category (%)	
	Cold Temperate Dry	Warm Temperate Dry
High Activity Clay Mineral	40.3	59.7
Low Activity Clay Mineral	55.7	44.3
Sandy	45.4	54.6
Aquic	39.6	60.4

Management

In Hungary full tillage of croplands was the only applied cultivation system until the end of 1990ies and it is still dominant, though the area cultivated with reduced tillage methods is increasing year by year. From 1998 in accordance with the combat against drought damages and soil degradation, conventional soil cultivation was prospectively replaced by conservation tillage methods, among them mainly which aims the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter. As the management of croplands considerably modifies soil C stocks, we estimated the area of the non-conventionally cultivated croplands. Among the main soil protective management practices that affect soil C stocks in croplands (e. g. residue management, reduced tillage, fertilizer management applying mineral fertilizers and organic amendments, irrigation management) reduced tillage is the most characteristic in Hungary recently. To account for changes in soil C stocks of croplands we estimated the areas of the two main cultivation types at the beginning and end of the inventory time period. There are no sufficient data available to estimate the correct actual area of reduced tillage hence the calculation is based on expert judgement. The principle of the calculation is that the total area of cereals (winter wheat, barley, maize) can be considered stable (approximately 2.6 million ha), the fluctuation is not considerable. The newly introduced soil protective cultivation methods are used mainly in the case of cereal production. We took the cumulative number of sold machines and tools that are suitable for reduced tillage into account since 1998 (source: KITE Ltd., the biggest company in agricultural service and commerce in Hungary), and calculated the extent of the area, where these machines and tools can be applied (one fourth of the actual area of cereals). According to our judgment, by the reported year of 2009, the area cultivated by applying one of these alternative methods was extended approximately to 245,300 hectares in Hungary.

<u>Input</u>
To choose the input factors (Table 7.15) that representing the agricultural practice in Hungary, the characteristics of crop rotations were taken into consideration. According to the GPG for LULUCF (IPCC, 2003), the input factors represent the effect of changing carbon input to the soil, as a function of crop residue yield, bare-fallow frequency, cropping intensity, or applying amendments. Therefore the four soil types representing the Hungarian croplands were divided further into three input categories. As the residue management is getting to be the part of the full till practice in a wider and wider extent, the proportion of the area of medium input for full till was enlarged of 5 percent while the territory of low input was decreased down to 47-50 percent from 50-55 in 2009 compared to the previous years on the base of expert judgment.

Table 7.15 *Classification of the croplands in Hungary by input in proportion to the total land in 2009*

Input category	Proportion of total cropland area (%)
Low	47
Medium	48
High with no manure	5

Low residue return is due to removal of residues, which is very characteristic to the growing technology of cereals (wheat, rye, barley) and a certain fraction of maize in Hungary. As the total are of cereals - except for maize - is approximately 1.4 million hectares, the proportion of the low input category is significant. We also have to take into consideration that crop residues are typically removed from a certain amount of the area of the crops listed under *medium* input.
Medium input cropping systems represent annual cropping with crops where crop residues are returned to the field. This way of growing is characteristic – besides some other less important crops - to maize, sunflower and sugar beet production. These three crops occupy approximately 1.8 million hectares annually. But as it was mentioned earlier, not the total area of these crops can be calculated in the *medium* input category.
High input (without manure) rotations are not widely used in Hungary, practically limited to the use of green manures and cover crops.

No area was taken into account belonging to the *high input (with manure)* category as regular addition of animal manure is not characteristic to the recent Hungarian agriculture.

Choice of stock change and emission/removal factors

For the reference carbon stocks (SOC_{REF}) the IPCC default values were applied in accordance with the Table 3.3.3 of the GPG for LULUCF (IPCC, 2003). The reference carbon stocks (SOC_{REF}) used in the Hungarian inventory are listed in Table 7.16.Taking the recent practice of soil cultivation and crop production into consideration the categorization of the croplands of Hungary has been made regarding the climate, soil type, management and input. Since extended country-specific stock change factors are not available in Hungary at the moment, the stock change factors were taken from the GPG for LULUCF (IPCC, 2003) Table 3.3.4. The stock change factors applied in the Hungarian inventory are shown in Table 7.17-7.19.

Table 7.16 *Soil type coverage and soil organic carbon stocks (SOC_{REF}) in Hungary (tC ha^{-1})*

Climate zone	High activity clay soils	Low activity clay soils	Sandy soils	Aquic soils
Cold temperate, dry	50	33	34	87
Warm temperate, dry	38	24	19	88

Table 7.17 *Land use factors (F_{LU})*

Land use level	Factors
Long term cultivated	0.82
Set aside<20 yrs	0.93

Table 7.18 *Management factors (F_{MG})*

Land use	Management regime	Factors
Cropland	full till	1.00
	reduced till	1.03

Table 7.19 *Input factors*

Land use	Input of organic matter	Factors
Cropland	low	0.92
	medium	1.00
	high- with no manure	1.07

Liming

Liming also showed a decreasing tendency in Hungary in the last decade (Figure 7.8), accordingly, the trend of emissions from liming was decreasing as well. Emissions from liming accounted for 9.7 Gg in 2009. Details of our estimation are shown in Table 7.20.

Table 7.20 *Carbon emissions from agricultural lime application in Hungary in 2009*

Climate	Soil	Type	Amount [t]	EF	ΔC_{CCLime} [Gg]
Cold	HAC	limestone	10,629	0.12	1.3
Cold	HAC	dolomite	0	0.122	0.0
Warm	HAC	limestone	7,016	0.12	0.8
Warm	HAC	dolomite	0	0.122	0.0
Cold	Sandy	limestone	7,925	0.12	1.0
Total			25,570		3.1

Choice of method and emission factors

The Tier 1 method and the default emission factors given by the GPG for LULUCF (IPCC, 2003) were used to estimate the emissions. Emission factor 0.12 was used to estimate CO_2 emissions due the application of carbonate containing lime, and 0.122 for dolomite.

Choice of activity data

Data on the amounts of agricultural lime application are not available in Hungary, therefore in order to calculate CO_2 emissions from application of carbonate containing lime (calcic limestone), or dolomite ($CaMg(CO_3)_2$) to agricultural soils, we had to determine the amount of carbonate containing chemical amendments used for soil reclamation in the reporting year.
The total area of the reclaimed soils was available from the statistical database of the Agricultural Economics Research Institute; (website: www.akii.hu) for the period of 2000-2006. Earlier data till 1999 can be found in the annual statistical pocket-books of the Hungarian Central Statistical Office. Nevertheless, the consistency of the data is ensured, as both institutions used the same data sources (regular agricultural surveys that cover agricultural enterprises as well as private farms). In the data bases the reclaimed soils include acidic, salt affected and sandy soil categories. The last category, i.e. sandy soils was not taken into account as a source of CO_2 emissions, as high organic matter containing amendments and not carbonate containing materials are added to these soils to increase their fertility,.
Unfortunately, no data are available after 2006 from the statistical database of the Agricultural Economics Research Institute; hence other sources had to be used to estimate the total area of reclaimed soils. The National Plant- and Soil Protection Directorates of the Central Agricultural Office have a directorate in each of the 19 counties of Hungary. If somebody wants to apply liming for amelioration on an agricultural field, permission must be asked from these directorates. Therefore the competent representatives of each directorate were asked for data concerning the permissions given for liming for amelioration purposes in 2009.

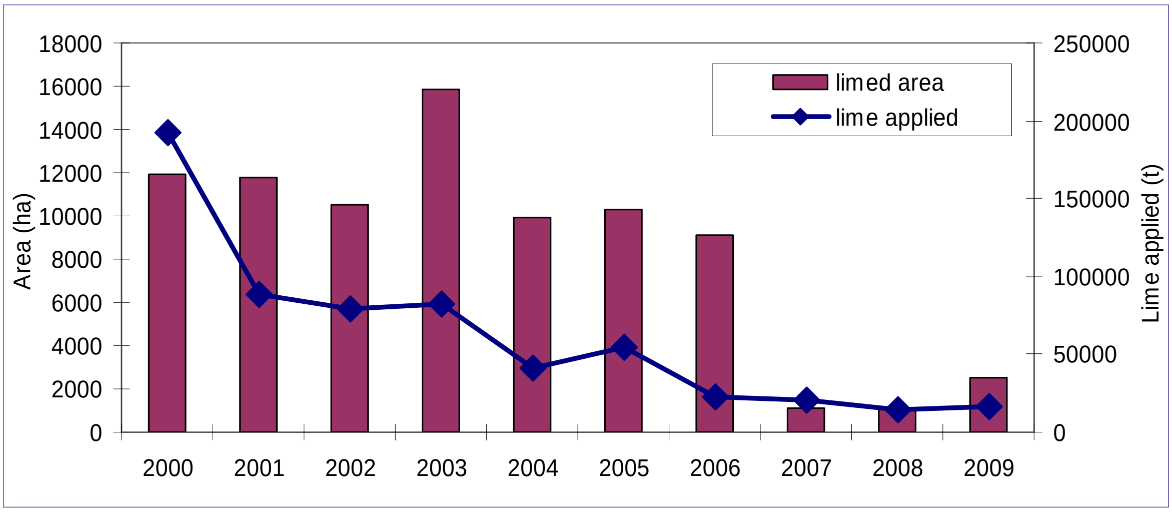


***Figure 7.8** The total area reclaimed by lime or dolomite and the amount of amendment applied in Hungary in the period of 2000- 2009 (lime fertilization is not included)*

The carbonate containing chemical amendments used for the reclamation of acidic soils are the followings: grinded limestone, grinded dolomite, beet potash, and other by-product potashes of different origin. In certain cases (in alkaline soils) gypsum is the proper chemical amendment to reclaim salt affected soils, but carbonate containing chemical amendments is also used.

The determination of the proportion of acidic and salt affected soils where carbonate containing lime or dolomite was used is based on expert judgement. According to this judgement two third of the acidic soils are reclaimed with limestone containing amendments while 27% with dolomite. In the case of salt affected soils half of them were estimated to be reclaimed with limestone or other carbonate containing material.

Organic soils

In Hungary all of the croplands can be found on mineral soils, no organic soils are under cultivation.

Forest Land converted to Cropland

See Chapter 7.2.3.

Grassland converted to Cropland

Carbon stock change in living biomass

In this category only the carbon stock change in living non-woody biomass is reported. All carbon stock change in Cropland living woody biomass is reported in 5.B.1 Cropland remaining Cropland category because of the aggregate Vineyard and Orchard removal statistics.

The carbon stock change in living biomass in category 5.B.2.2 Grassland converted to Cropland amounted to 5.34 Gg C in 2009.

Choice of methodology

The Equation 3.3.8 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LCLB} = A_{\ Conversion} \cdot (L_{Conversion} + \Delta C_{Growth})$$

$L_{Conversion} = C_{After} - C_{Before}$

Where:
ΔC_{LCLB}= Carbon stock change in Cropland living biomass in land converted to Cropland category, tonnes C year^{-1}
$A_{Conversion}$ = annual area of land converted to Cropland
$L_{Conversion}$= Carbon stock change per area for the type of conversion when land is converted to Cropland tonnes C ha^{-1}
C_{After}= carbon stocks in living biomass after the conversion to Cropland tonnes C ha^{-1}
C_{Befor}= carbon stocks in living biomass before the conversion to Cropland tonnes C ha^{-1}

In accordance with the Tier 1 assumption the carbon stock of living biomass immediately after conversion was considered to be zero. (C_{After}=0)

Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The proportion of grassland converted to annual croplands to grassland converted to (annual and perennial) croplands were determined from the land cover-change databases for the periods 1985-1992, 1992-2000 and 2000-2009. The calculated proportions are 98, 99 and 95 percent respectively. The estimated activity data are presented in Table 7.21.

***Table 7.21** Activity data of carbon stock change in living biomass in category 5.B.2.2 (ha)*

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Areas of grassland converted to annual cropland	4,797	5,596	4,797	7,195	7,195	7,195	7,195	0	0	8,211	8,211	8,211	8,211
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Areas of grassland converted to anual cropland	8,211	8,211	8,211	8,211	2,838	2,838	2,838	2,838	2,838	2,838	2,838	2,838	2,838

Choice of emission factors

In reference to ΔC_{Growth} the IPCC default value of 5 tonnes per hectare suggested for annual crops was accounted (Table 3.3.8 of the GPG for LULUCF). It is important to note that only areas converted to annual crops is reported in this category. Carbon stock change in perennial biomass of Croplands is reported in 5.B.1 Cropland remaining Cropland category.
For carbon stocks of before conversion (C_{Before}) the default carbon stocks values provided in Table 3.3.7 and Table 3.4.2 of GPG for LULUCF (IPCC, 2003) were applied.
The default values in Table 3.4.2 are provided for the dry matter of above ground biomass, therefore the carbon stocks were calculated as follows, in accordance with the Equation 3.4.6 of GPG for LULUCF (IPCC, 2003):

$C_{Before} = CF \cdot (B_{AG}+B_{BG})$
$B_{BG=} B_{AG} \cdot (1+R)$

Where:
CF= carbon fraction of dry matter, tonnes C (tonnes d.m.) $^{-1}$

B_{AG}= aboveground biomass, tonnes d.m. ha^{-1}
B_{BG}= belowground biomass, tonnes d.m. ha^{-1}
R= root to shoot ratio

For the CF the IPCC default value 0.5 was applied. While for the R the IPCC default value provided in Table 3.4.3 of GPG for LULUCF (IPCC, 2003) for semi arid grasslands was taken into account (R=2.8). Hungarian grasslands situated in cold dry and warm dry climate zones, therefore in accordance with the Table 3.4.2 of the GPG for LULUCF (IPCC, 2003) the aboveground perennial biomass (B_{AG}) is 1.7 tonnes d.m. ha^{-1} in the cold dry climate zone and 1.6 tonnes d.m. ha^{-1} in the warm climate zone. The total above ground biomass was calculated in the proportion of distribution of grasslands by climate zones. (It was assumed that 41 percent of converted grasslands situated in cold dry and 59 percent in warm dry climate zone.
According to the calculation as described above in Hungary
$-0.5 \cdot (0.41 \cdot 1.7+0.59 \cdot 1.6) \cdot (1+2.8)+5=1.88$ tC ha^{-1} is the carbon stock change in the living non-woody biomass on grasslands converted to annual cropland.

<u>Carbon stock change in soils</u>

Mineral soils

Carbon stock change in mineral soils in category 5.B.2.2 Grassland converted to Cropland amounted to -66.4 Gg C in 2009.
The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Cropland remaining Cropland sub-category above, but in case of land-use conversion, the SOC_0 is the *average* soil organic carbon stock of the land-use category in the inventory year (Cropland) and SOC_{0-T} is the *average* soil organic carbon stocks for the former land-use category, T years prior to the inventory year (Grassland), and A is the converted area.
The calculated average carbon stocks of mineral soils in Cropland and Grassland are provided in Table A3-8 - A3-11 in Annex A3.4.

Liming

No liming was reported for this sub-category.

Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under cultivation.

Liming

No liming was reported for this sub-category.

Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under

cultivation.

7.3.3. Uncertainties and time-series consistency

As uncertainty assessment includes the degree of accuracy in land area estimates and in the default carbon accumulation and loss rates. It was considered partly on the base of the uncertainty estimates for IPCC default values taken from the GPG for LULUCF (IPCC, 2003) and partly based on expert judgment. Where they were available, estimates of the uncertainty of the revised global default values were used with the appropriate estimates of variability. Like in the cases of default values of stock change factors. Uncertainty in the land areas involved in land-use and management changes was estimated by expert judgement. The land area data of croplands originate from administrative records of the Hungarian Central Statistics Office. These records are based on regular agricultural surveys that cover agricultural enterprises as well as private farmers. The bigger enterprises are surveyed on a full-scope basis, while smaller private farmers on a representative basis by stratified sampling. The land area data gained from the administrative records (source: Annual Yearbooks of HCSO) were stratified further based on expert judgement as described above in the *Choice of activity data* paragraph.

Table 7.22 *Uncertainties of emissions from Cropland category*

AREAS	
Input data	**Uncertainty %**
Area stratified by soil type	25
Area stratified by climate	25
Area stratified by management	25
Area stratified by input	25
FACTORS	
Input data	**Uncertainty %**
Long-term cultivated land use	10
Full tillage	NA
Reduced tillage	6
Low input	4
Medium input	NA
High input with no manure	10
AMOUNT	
Limestone and dolomite applied	50

7.3.4. Category-specific recalculations

Following the recommendations from the in-country review conducted in 2010 the classification of land areas has been reconsidered. Set-aside croplands have been reallocated from the Other Land category to the Cropland category. Together with this relocation other changes were also made. Following are the detailed changes leading to recalculations in the 5.B Cropland category.

- Reallocation of emissions/removals from the 5.B.2.5 Other Land converted to Cropland and 5.F.2.2 Cropland converted to Other Land subcategories to the 5.B.1 Cropland remaining Cropland subcategory.
- Revision of cropland areas in line with the General Agricultural Survey (HCSO, 2010) for the period 2001-2008.
- Revision of area data by the CAO for 5.B.2.1 Forest Land converted to Cropland for

2005-2008.

- Inclusion of emissions from carbon stock change in dead organic matter in 5.B.2.1 Forest Land converted to Cropland sub-category for the years 1985-2008.
- Adjustment of set-aside agricultural areas (including set-aside croplands) arising from the adjustment of Wetland and Settlements areas and conversions for the period 1985-2008.
- Inclusion of CH_4 and N_2O emissions from wildfires for the period 1985-2008.
- Omission of N_2O emissions from land disturbance associated to land-use conversion from Other Land converted to Cropland for the period 1985-2008. (In the previous submission the re-use of set-aside croplands for cropland were reported in this category.)

The overall impact of the recalculation on the CO_2 emissions of all years from 5.B Cropland can be seen in Table 7.23. The recalculation resulted in one order of magnitude lower or higher emissions/removals in some of the years. The changes in the CO_2 emissions/removals are in the range -547 to 51 Gg CO_2 with an average of -274 Gg CO_2. The bulk of the changes can been explained by the reallocation of the set-aside croplands from the Other Land category into the 5.B.1 Cropland remaining Cropland category, although the effect of the adjustment of the croplands is also significant in the period 2001-2008.

The changes in the non-CO2 emissions due to recalculations are negligible compared to the changes in the CO_2 emissions. (The change in non-CO_2 emissions range in 3 to 34 Gg CO_2-eq with an average of 21 Gg CO_2-eq.)

Table 7.23 *Recalculation of CO_2 emissions from 5.B Cropland 1985-2008*

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg]	613	1,208	359	407	-326	-801	478	487	
Submission 2011 [Gg]	664	1,210	378	404	-336	-817	461	429	
Difference	51	3	20	-3	-10	-16	-18	-58	
Percentage change	8.3%	0.2%	5.5%	-0.8%	3.1%	2.0%	-3.7%	-11.9%	
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	
Submission 2010 [Gg]	182	-142	-104	-72	-15	110	109	159	
Submission 2011 [Gg]	86	-298	-319	-345	-347	-278	-341	-352	
Difference	-96	-156	-215	-273	-332	-388	-450	-510	
Percentage change	-52.7%	110.4%	207.8%	382.3%	2176.6%	-352.8%	-413.0%	-321.7%	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Submission 2010 [Gg]	207	339	543	479	403	506	407	408	285
Submission 2011 [Gg]	-340	-183	86	23	-49	25	-42	-112	-225
Difference	-547	-522	-457	-456	-452	-481	-449	-520	-510
Percentage change	-263.8%	-153.8%	-84.2%	-95.3%	-112.2%	-95.0%	-110.3%	-127.4%	-178.9%

7.3.5. Category-specific planned improvements

Development of country-specific values for the reference carbon stocks of mineral soils.

7.4. GRASSLAND (CRF sector 5.C)

7.4.1. Description of category

Although nowadays the area of grasslands is accounting for 13 percent of the official area of Hungary, the area of grasslands utilized for agricultural purposes (meadows and pastures) decreased considerably during the last three decades. While 1,246,400 ha Grassland were utilized in 1985, only 791,000 ha remained by 2009 as shown in Table 7.24. From the base year the decrease of meadows and pastures areas were 36%.

Table 7.24 *Grassland area 1985-2009*

Year	Area [1,000 ha]		
	Grassland	Set-Aside Grassland	Total Grassland
1985	1,246	40	1,287
BY	1,234	47	1,281
1986	1,234	50	1,284
1987	1,222	51	1,274
1988	1,210	53	1,263
1989	1,197	55	1,252
1990	1,186	56	1,242
1991	1,172	82	1,254
1992	1,159	108	1,267
1993	1,145	119	1,264
1994	1,132	129	1,261
1995	1,118	139	1,258
1996	1,105	149	1,254
1997	1,092	159	1,251
1998	1,078	169	1,247
1999	1,065	178	1,243
2000	1,051	188	1,239
2001	1,022	212	1,235
2002	993	237	1,230
2003	965	262	1,227
2004	936	287	1,223
2005	907	314	1,221
2006	878	339	1,217
2007	849	363	1,212
2008	820	388	1,209
2009	791	414	1,206

Contrary to this trend, the change in the number of livestock of grazing animals (mainly cattle, sheep and geese as the livestock of horses, water buffalos and goats were not so considerable from the 1970ies) was something different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million sheep were in Hungary, and these numbers just slightly changed till 1985: 2 million cattle, 1 million geese and 3 million sheep. These numbers show that the decade of the 1980ies was the peak period concerning animal husbandry based on grazing, which was also the period of the highest natural expenditures regarding the utilization of the Hungarian grasslands: the highest fertilizer doses and the largest irrigated areas characterized this period. It can be concluded that the number of grazing animals and the intensity of grassland both started to decrease from the base year and reached its bottom in the middle of the 1990ies.

The trend in emissions/ removals from the Grassland category can be explained by the above mentioned changes. (Figure 7.9)

It should be noted, that the HCSO records grasslands which are used for agricultural purposes. Abandoned pastures and natural grasslands are reported as 'unproductive areas' in this statistics therefore the annual areas of the set-aside grasslands were estimated from the compilation of the HCSO's land-use statistics and CLC-change databases.

CO_2 removals and emissions from living biomass due to land-use conversions and mineral soils are reported under this category. (Organic soils are not used for agricultural purposes in Hungary.) The CO_2 emission from category 5.C Grassland was 246 Gg in 2009. Figure 7.9 shows the trends in emissions and removals from Grassland over the period 1985-2009.

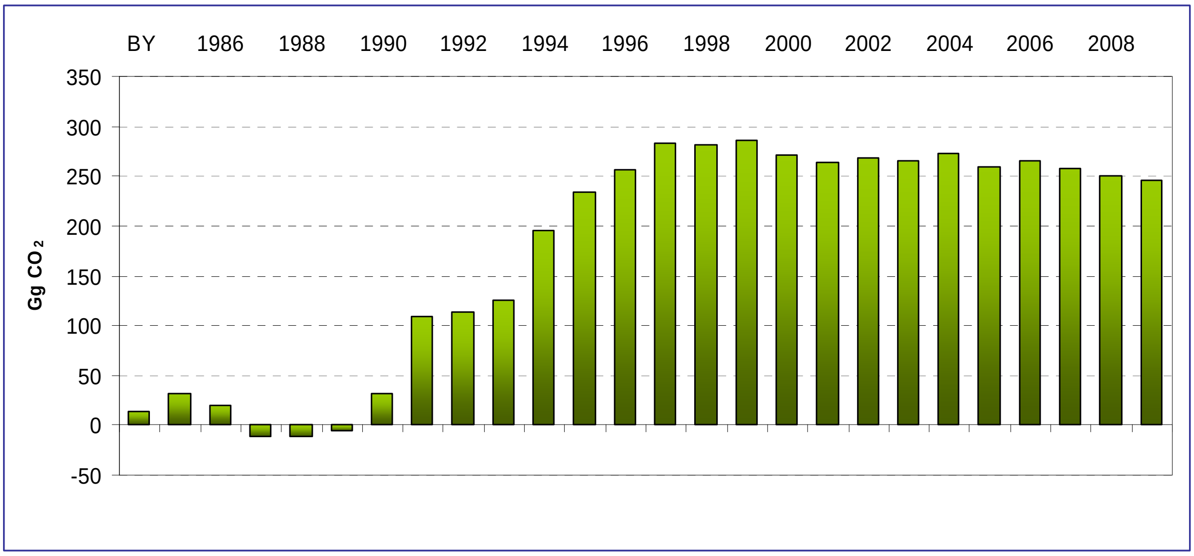


Figure 7.9 *Trend in emissions/removals from category 5.C Grassland 1985-2009*

7.4.2. Methodological issues

Grassland remaining Grassland

This category comprises emissions and removals from the change of management practices (including the effects of the abandonment) on grasslands.

Carbon stock change in living biomass

Choice of method

In Hungary grassland management practices can be considered static, so according to Tier 1 method, no change in living biomass carbon stock was estimated. In CRF table 5.C.1 NO are reported.

Carbon stock change in soils

Grassland management, similarly to soil cultivation and crop production, is changing in

Hungary, but contrary to the other sector's slight improvements, it suffers from degradation. The improper grassland management practice has severe impacts on the soil carbon stock. Though in Hungary there are no extensive measured data yet, some results have been already achieved concerning CO_2-emission from grasslands (Nagy et al.. 2007, Zsembeli et al. 2006).

According to the summary Equation 3.3.2 of GPG for LULUCF (IPCC, 2003), the change in organic carbon stocks in soils is

$$\Delta C_{GGSoils} = \Delta C_{GGMineral} - \Delta C_{GGOrganic} - \Delta C_{GGLime}$$

Where:
$\Delta C_{GGSoils}$ = annual change in carbon stocks in soils in Grassland remaining Grassland, tonnes C yr^{-1}
$\Delta C_{GGMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{GGOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{GGLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}.

$\Delta C_{GGOrganic}$=0, because grasslands on organic soils not used for agricultural purposes in Hungary.
ΔC_{GGLime}=0, because lime application on grasslands are negligieble in Hungary.
Taking these components into account, the total annual soil carbon stock change in the category 5.C.1 Grassland remaining Grassland in Hungary amounted to -119 Gg C in 2009.

Mineral soils

In 2009 the mineral soils in category 5.B.1 Grassland remaining Grassland was a source of 119 Gg C.

Choice of method

The Tier 1 method of GPG for LULUCF (IPCC, 2003) was applied, similar to the cropland remaining cropland category. The carbon stock change was calculated from the average carbon stocks. The calculated average carbon stocks are provided in Table A3-10 and A3-11 in Annex A3-4.

Choice of activity data

In order to gain relevant activity data, the area of grasslands was stratified by soil type, climate, management and input.

Soil type

The method of the classification of the Hungarian grasslands according to soil types is based on the same approach that is described in the Cropland chapter (7.2). The grasslands in Hungary occupied four soil types from among the types that are determined in the *IPCC Good Practice Guidance for LULUCF (2003)* with following proportions of the total land in 2008.

Table 7.25 *Classification of the grasslands in Hungary by soil type in proportion to the total land*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	74.01
Low Activity Clay Mineral	4.25
Sandy	4.10
Aquic	17.64

As the proportions show, high activity clay mineral soils are dominant, similar to the case of croplands. Among others salt affected soils must be mentioned, which are very characteristic to Hungary, they are partly utilized as grasslands, mainly depending on the extent of salinization.

Climate

The principle of climatic classing, which is described in the Cropland section in details, is also relevant to the grasslands.

Management

Due to the lack of sufficient statistic data, the quality, hence the management of grasslands was determined on the base of the number of grazing animals and the level of expenditures for each soil type and climate region, taking the spatial distribution of livestock into consideration. The different species of grazing animals were standardized and expressed in livestock units. The spatial distribution of quality, utilization, load, hence management types of grasslands were estimated on the base of genetic soil maps and climatic zone maps. Taking all these points of view into account, the following simplified categories characterize the management of the Hungarian grasslands: non-degraded, improved with medium input.

Input

According to the GPG for LULUCF (IPCC, 2003), the input factors represent the level of improvement that affects primary productivity and hence carbon inputs to soil. To choose the input factors representing the grassland management in Hungary, the actual levels of fertilization and irrigation were taken into consideration. Beyond the decrease of the number of livestock, the area of fertilized and irrigated grasslands was totally forced back parallel to the introduction of Agro-environmental Management Programme in 2002-2003, and was limited to slightly intensive planted grasslands. This was the reason why the natural succession of the pastures has started, resulting in the propagation of weeds and the degradation of the soil. Further harms were due to the unfavourable weather conditions of the last 5-6 years, when the droughty summer periods in conjunction with slight overgrazing made the situation even worse. Taking all these into consideration it can be concluded that significant changes occurred in the Hungarian grassland management during the last decades. The recent situation is that only half of the pastures in Hungary is utilized by grazing. The management, the treatment of grasslands is limited to their grazing and cutting.

Table 7.26 *Classification of the grasslands in Hungary by management in proportion to the total land in 2009*

Management category	Input category	Proportion of total grassland area (%)
non-degraded	-	99.6
improved	medium	0.4

Choice of stock change and emission factors

The categorization is partly based on expert judgement due to the lack of sufficient statistics about the recent management and input applied grassland management practice. Nevertheless the change in the management practice can be judged well on the base of the number of grazing animals and the degree of expenditures, while the input can be followed knowing the extent of fertilisation and irrigation of grasslands. The categorization of the grasslands of Hungary has been made regarding the climate, soil type, management and input.
The coverage of soil type and the applied soil organic carbon stocks was the same as that summarized in Table 7.13 in Chapter 7.3. The Land-use factor (F_{LU}) was 1.0 for all grasslands, according to the GPG for LULUCF (IPCC 2003). The management factors (F_{MG}) are shown in Table 7.27. The level of input (F_I) was assumed to be 1.0 for the improved grassland as well as nominally managed grassland.

Table 7.27 *Management factors (F_{MG})*

Land use	Management regime	Factors
Grassland	Nominally managed (non-degraded)	1.00
	Improved	1.14

Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.

Organic soils

In Hungary no organic soils are under agricultural grassland management.

Forest Land converted to Grassland

See Chapter 7.2.3

Cropland converted to Grassland

Carbon stock change in living biomass

In this category only carbon stock change in living biomass of annual croplands converted to grasslands is reported. All carbon stock changes in perennial croplands living biomass are reported in category 5.B.1 Cropland remaining Cropland because of the aggregate Vineyard and Orchard removal statistics.
The carbon stock change in living non-woody biomass in category 5.C.2.2 Cropland converted to Grassland amounted to -3 Gg C in 2009.

Choice of methodology

Equation 3.3.8 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LGLB} = A_{Conversion} \cdot (L_{Conversion} + \Delta C_{Growth})$$
$$L_{Conversion} = C_{After} - C_{Before}$$

Where:

ΔC_{LGLB}= Carbon stock change in living biomass due to land-use conversion to Grassland, tonnes C year^{-1}
$A_{Conversion}$ = annual area of land converted to Grassland

$L_{Conversion}$= Carbon stock change per area for the type of conversion when land is converted to Grassland tones C ha^{-1}
C_{After}= carbon stocks in living bimass after the conversion to Grassland, tonnes C ha^{-1}
C_{Befor}= carbon stocks in living bimass before the conversion to Grassland, tonnes C ha^{-1}

Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The proportion of “annual cropland converted to grassland” to “(annual and perennial) croplands converted to grassland” were determined from the land cover-change databases for the periods 1985-1992, 1992-2000 and 2000-2008. The calculated proportions are 97, 92 and 90 percent respectively. The estimated activity data are presented in Table 7.28.

Table 7.28 *Activity data for carbon stock change in living biomass in category 5.C.2.2*

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Area of annual Cropland converted to Grassland	5,153	3,435	5,153	0	0	0	0	15,459	15,459	6,137	6,137	6,137	6,137
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Area of annual Cropland converted to Grassland	6,137	6,137	6,137	6,137	1,657	1,657	1,657	1,657	1,657	1,657	1,657	1,657	1,657

Choice of emission factors

In accordance with the Tier 1 assumption, the carbon stock of living biomass was considered to be zero immediately after conversion. (C_{After}=0).
For C_{Before} the IPCC default value, given for annual croplands were taken into account (5 tC ha^{-1}).
ΔC_{Growth} was calculated in accordance with the Tier 1 assumptions of the GPG for LULUCF (IPCC, 2003):
$\Delta C_{Growth} = 0.5 \cdot (0.41 \cdot 6.5 + 0.59 \cdot 6.1)$
The total above- and belowground biomass was calculated in the proportion of distribution of grasslands by climate zones using the IPCC default values provided in Table 3.4.9 of GPG for LULUCF (IPCC, 2003) for LULUCF. (It was assumed that 41 percent of converted grasslands situated in cold dry, and 59 percent in warm dry climate zone.)

Carbon stock change in soils

Mineral soils

Carbon stock change in mineral soils in category 5.C.2.2 Cropland converted to Grassland amounted to 58 Gg C in 2009.
The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Cropland remaining cropland sub-category (Chapter 7.2) but in case of land-use conversion the SOC_0 is the *average* soil organic carbon stock of the land-use category in the inventory year (Cropland) and SOC_{0-T} is the *average* soil organic carbon stocks for the former land-use

category (Grassland), T years prior to the inventory year, and A is the converted area. Calculated average carbon stocks of mineral soils for Croplands and for Grassland are provided in Table A3-8A3-11 in Annex A3.4.

Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.

Organic soils

In Hungary no organic soils are under agricultural grassland management.

7.4.3. Uncertainties and time-series consistency

As uncertainty assessment includes the degree of accuracy in land area estimates and in the default carbon accumulation and loss rates. It was considered partly on the base of the uncertainty estimates for IPCC default values taken from the GPG for LULUCF (IPCC, 2003) and partly based on expert judgment. Where they were available, estimates of the uncertainty of the revised global default values were used with the appropriate estimates of variability, like in the cases of default values of stock change factors. Uncertainty in the grassland areas involved in land-use and management changes was estimated by expert judgment. The land area data of grasslands originate from administrative records of the Hungarian Central Statistics Office. These records are based on regular agricultural surveys that cover agricultural enterprises as well as private farmers. The bigger enterprises are surveyed on a full-scope basis, while smaller private farmers on a representative basis by stratified sampling. The land area data gained from the administrative records (source: Annual Yearbooks of HCSO) were stratified further based on expert knowledge as described above in the *Choice of activity data* paragraph.

Table 7.29 *Uncertainties of emissions from Grassland category*

AREAS	
Input data	**Uncertainty %**
Area stratified by soil type	25
Area stratified by climate	25
Area stratified by management	25
Area stratified by input	25
FACTORS	
Input data	**Uncertainty %**
Land use as grassland	NA
Nominally managed (non-degraded)	NA
Improved management	10
Medium input	NA

7.4.4. Category-specific recalculations

Following the recommendations from the in-country review conducted in 2010 the classification of land areas has been reconsidered. Set-aside grasslands have been reallocated from the Other Land category to the Grassland category. Together with this relocation other changes were also made. Following are the detailed changes leading to recalculations in the 5.C Grassland sector.

- Reallocation of emissions/removals from the 5.C.2.5 Other Land converted to Grassland and 5.F.2.3 Grassland converted to Other Land subcategories to the 5.C.1

Grassland remaining Grassland subcategory.

- Revision of grassland areas in line with the General Agricultural Survey (HCSO, 2010) for 2001-2008.
- Correction of transcription error between calculation sheet and CRF Reporter Table 5.C.2.1 Forest Land converted to Grassland.
- Adjustment of set-aside agricultural areas (including set-aside grasslands) arising from the adjustment of Wetland and Settlements areas and conversions.
- Inclusion of previously not reported emissions from carbon stock change in dead organic matter in 5.C.2.1 Forest Land converted to Grassland sub-category for the years 1985-2008.
- Inclusion of previously not reported CH_4 and N_2O emissions from wildfires for the period 1985-2008.

The overall effect of the recalculation on the CO_2 emissions of all years from 5.C Grassland can be seen in Table 7.30. The changes in the CO_2 emissions/removals are in the range -28 to 41 Gg with an average of 18%. The bulk of the changes can been explained by the reallocation of the set-aside grasslands from the Other Land category into the 5.C.1 Grassland remaining Grassland category, although the effect of the adjustment of the grasslands is also significant in the period 2001-2008.

The changes in the non-CO_2 emissions due to recalculations are negligible compared to the changes in the CO_2 emissions. (The change in non-CO_2 emissions range in 0.1 to 2.1 Gg CO_2-eq with an average of 1.1 Gg CO_2-eq.)

Table 7.30 shows the recalculation of CO_2 emissions from 5.C Grassland subcategory.

***Table 7.30** Recalculation of emissions from 5.C Grassland 1985-2008*

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg]	27	48	32	1	-1	4	60	101	
Submission 2011 [Gg]	14	32	20	-11	-12	-5	32	109	
Difference	-13	-16	-12	-11	-10	-9	-28	9	
Percentage change	-48%	-33%	-36%	-1926%	686%	-238%	-47%	9%	
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	
Submission 2010 [Gg]	78	99	164	206	215	243	251	246	
Submission 2011 [Gg]	114	126	195	234	256	283	282	286	
Difference	36	27	31	28	41	39	31	40	
Percentage change	47%	27%	19%	14%	19%	16%	12%	16%	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Submission 2010 [Gg]	273	231	246	261	284	229	258	222	215
Submission 2011 [Gg]	271	264	268	266	273	259	265	258	250
Difference	-1	33	22	5	-11	30	8	35	35
Percentage change	-1%	14%	9%	2%	-4%	13%	3%	16%	16%

7.4.5. Category-specific planned improvements

Development of country-specific values for the reference carbon stocks of mineral soils.

7.5. Wetlands (CRF sector 5.D)

Wetlands account for only 3 percent of the total area of Hungary. (Figure 7.1)
According to the national definition, areas of wetlands comprise inland marshes, peat bogs, water courses and water bodies. The Wetlands area was determined by extrapolation and interpolation from the HLC-Changes$_{1985-1990}$, CLC-Changes$_{1990-2000}$, HLC-Changes$_{2000-2006}$ and CLC2006 databases. CORINE is a land cover database therefore managed and unmanaged lands cannot be separated by it. To determine the area of flooded lands and peat lands, which is the managed area of Wetlands in terms of the GPG for LULUCF (IPCC, 2003), additional information should be used, which is currently not available.
In order to create land-use matrices, area of Wetlands was split into remaining and converted to category using the CORINE land-cover change databases, although the land-cover changes are probably not human-induced. The emissions of converted to Wetlands categories are not estimated due to lack of reliable area data and developed methodology. Nevertheless, these emissions could not be significant because the total Wetland area did not change remarkably due to human intervention, since wetlands are protected ex lege in Hungary. Hungary is among the signatories of the Ramsar Convention, therefore the preservation and the sustainable uses of Wetlands are emphasized. In 2009, altogether 28 wetlands (225,011 ha) in Hungary had been included in the Ramsar List of Wetlands of International Importance.
In this category only the area data are reported in the CRF tables.

7.6. Settlements (CRF sector 5.E)

7.6.1. Description of category

Settlements account for 6 percent of the area of Hungary.
The area of Settlements is derived from extrapolation and interpolation of the HLC-Changes$_{1985-1990}$, CLC-Changes$_{1990-2000}$, HLC-Changes$_{2000-2006}$ and, CLC2006. The land-use change data were determined from the HLC-change$_{1985-1990}$, CLC-change$_{1990-2000}$, CLC-change$_{2000-2006}$ databases. (For more details see Chapter 7.1 and Annex A3.4.) In this submission area data in the remaining and in the converted to category and emissions from 5.E.2.1 Forest Land converted to Settlements, 5.E.2.2 Cropland converted to Settlements and 5.E.2.3 Grassland converted to Settlements are reported.

7.6.2. Methodological issues

Settlements remaining Settlements

Not reported. (Parties may decide not to prepare estimate for this category.)

Land converted to Settlements

For the estimation of emissions from these conversions a conservative approach was applied, due to a lack of suitable activity data on the living biomass and mineral soils of Settlements. It was assumed, that the areas, which are converted to settlements are paved over during the conversions, therefore there is not any living biomass after the conversions (carbon stocks in living biomass immediately after conversion to settlements and the change in carbon stocks from one year of settlements growth are zero), and 20% of the soil carbon relative to the previous land use will be lost as a result of disturbance, removal, or relocation. Therefore in the estimation of emissions from living biomass C_{After}=0 and ΔC_{Growth} =0. In the estimation of emissions from mineral soils $\Delta C_{LSMineral}=-0.2 \bullet SOC_0 \cdot A/T$.

Forest land converted to Settlements

See Chapter 7.2.3.

Cropland converted to Settlements

<u>Carbon stock change in living biomass</u>

In this category only carbon stock change in living biomass of annual croplands converted to Settlements is reported. All carbon stock changes in perennial croplands living biomass are reported in category 5.B.1 Cropland remaining Cropland because of the aggregate Vineyard and Orchard removal statistics.
The carbon stock change in living non-woody biomass in category 5.E.2.2 Cropland converted to Cropland amounted to -9.5 Gg C in 2009.

<u>Choice of methodology</u>

Equation 3.6.1 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$\Delta C_{LSLB} = A_{Conversion} \bullet (-C_{Before})$

Where:

ΔC_{LSLB}= Carbon stock change in living biomass due to land-use conversion to Settlements, tones C year^{-1}

$A_{Conversion}$ = annual area of land converted to Settlements
$L_{Conversion}$= Carbon stock change per area for the type of conversion when land is converted to
C_{Before}= carbon stocks in living biomass before the conversion to Settlements, tones C ha^{-1}

Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The proportion of "annual cropland converted to settlements" was determined from the land cover-change databases for the periods 1985-1992, 1992-2000 and 2000-2009. The calculated proportions are 97, 92 and 90 percent respectively. The estimated activity data are provided in Table 7.31.

Table 7.31 *Activity data of carbon stock change in living biomass in category 5.E.2.2*

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Area of annual Cropland converted to Settlements	817	817	817	817	817	817	817	817	817	892	892	892	892
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area of annual Cropland converted to Settlements	892	892	892	892	1,908	1,908	1,908	1,908	1,908	1,908	1,908	1,908	1,908

Choice of emission factors

For C_{Before} the IPCC default value, given for annual croplands were taken into account (5 tC ha^{-1}).

Carbon stock change in soils

Mineral soils

Carbon stock change in mineral soils in category 5.E.2.2 Cropland converted to Settlements amounted to -10.7 Gg C in 2009.

For the details of the estimation of the SOC_0 of Cropland see Chapter 7.3.
Calculated average carbon stocks of mineral soils for Croplands in Table A3-8 and A3-9 in Annex A3.4.

Grassland converted to Settlements

Carbon stock change in living biomass

The carbon stock change in living biomass in category 5.E.2.3 Grassland converted to

Settlements amounted to -1.7 Gg C in 2009.

Choice of methodology

Equation 3.6.1 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$\Delta C_{LSLB} = A_{Conversion} \bullet (-C_{Before})$

Where:

ΔC_{LSLB}= Carbon stock change in living biomass due to land-use conversion to Settlements, tones C year^{-1}
$A_{Conversion}$ = annual area of land converted to Settlements
C_{Before}= carbon stocks in living biomass before the conversion to Settlements, tones C ha^{-1}

Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The proportion of "annual cropland converted to settlements" was determined from the land cover-change databases for the periods 1985-1992, 1992-2000 and 2000-2009. The calculated proportions are 97, 92 and 90 percent respectively. The estimated activity data are provided in Table 7.32.

Table 7.32 *Activity data of carbon stock change in living biomass in category 5.E.2.3*

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Area of Grassland converted to Settlements	391	391	391	391	391	391	391	391	391	297	297	297	297
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area of Grassland converted to Settlements	297	297	297	297	538	538	538	538	538	538	538	538	538

Choice of emission factors

C_{Before} was estimated from the IPCC default values (3.132 tC ha^{-1}). For more details see "Grassland converted to Cropland" in Chapter 7.3.

Carbon stock change in soils

Mineral soils

Carbon stock change in mineral soils in category 5.E.2.3 Grassland converted to Settlements amounted to -4.2 Gg C in 2009.

For the details of the estimation of the SOC_0 of Grassland see Chapter 7.4.
Calculated average carbon stocks of mineral soils for Grasslands in Table A3-10 and A3-11 in Annex A3.4.

7.6.3. Uncertainties and time-series consistency

No data available.

7.6.4. Category-specific recalculations

Recalculations have been undertaken in the 5.E Settlements category over the full time-series to account for the following improvements:

- Minor adjustment of the area of Settlements. For more details of the adjustment see chapter 7.10. Change in the are data are shown in Table 7.35
- Revision of area data by the CAO for 5.B.2.1 Forest Land converted to Settlements for 2005-2008.
- Inclusion of previously not reported emissions from carbon stock change in dead organic matter in 5.E.2.1 Forest Land converted to Grassland sub-category for the years 1985-2008. For more details see Chapter 7.2.
- Inclusion of previously not reported emissions from 5.E.2.2 Cropland converted to Settlements and 5.E.2.3 Grassland converted to Settlements.
- Correction of transcription error between calculation sheet and CRF Reporter Table 5.C.2.1 Forest Land converted to Settlements over the full time series.

The effect of the recalculation on the CO_2 emissions of all years from 5.E Settlements can be seen in Table 7.33. The changes in the CO_2 emissions are in the range -44 to 182 Gg with an average of 89 Gg. The bulk of the changes can been explained by the inclusion of previously not reported emissions from 5.E.2.2 Cropland converted to Settlements.

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***Table 7.33** Recalculation of CO_2 emissions from 5.E Settlements 1985-2008*

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg]	27	48	32	1	-1	4	60	101	
Submission 2011 [Gg]	14	32	20	-11	-12	-5	32	109	
Difference	-13	-16	-12	-11	-10	-9	-28	9	
Percentage change	-48%	-33%	-36%	-1926%	686%	-238%	-47%	9%	
	1992	1993	1994	1995	1996	1997	1998	1999	
Submission 2010 [Gg]	78	99	164	206	215	243	251	246	
Submission 2011 [Gg]	114	126	195	234	256	283	282	286	
Difference	36	27	31	28	41	39	31	40	
Percentage change	47%	27%	19%	14%	19%	16%	12%	16%	
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Submission 2010 [Gg]	273	231	246	261	284	229	258	222	215
Submission 2011 [Gg]	271	264	268	266	273	259	265	258	250
Difference	-1	33	22	5	-11	30	8	35	35
Percentage change	-1%	14%	9%	2%	-4%	13%	3%	16%	16%

7.6.5. Category-specific planned improvements

Development of country-specific values for the reference carbon stocks of mineral soils.

7.7. Other Land (CRF sector 5.F)

7.7.1. Description of category

The Other Land category includes the sparsely vegetated areas, which account for 0.03 percent of the total area of the country. (Figure 7.1) The area of the Other Land category was estimated from the CORINE datasets. The Other Land areas are unmanaged, therefore emissions from this category are not reported.
Although areas of Grassland converted to Other Land indicated CLC-changes$_{2000\text{-}2006}$ are reported in the CRF Table 5.F, but emissions from this conversion are not reported in accordance with the GPG (IPCC, 2003), because it was taken place on unmanaged land, and it is assumed not to be human induced land-use conversion.

7.8. Non-CO2 emissions

7.8.1. Direct N_2O emissions from fertilization (CRF sector 5(I))

Hungary has an aggregate fertilization database, which derives from sales statistics. Fertilization in the different land-use categories cannot be distinguished. The total nitrogen content of the used fertilizer is taken into account under the Agriculture sector.

7.8.2. N_2O emissions from drainage of soils (CRF sector (5(II))

Parties do not have to prepare estimates for the categories contained in appendices 3a.2, 3a.3. Hungary does not have sufficient information to prepare estimates in this category.

7.8.3. N_2O emissions from disturbance associated to land-use conversion to Cropland (CRF sector 5(III))

N_2O emissions from disturbance associated to land-use conversion to Cropland are calculated for mineral soils in 5.B.2.1 Forest Land converted to Cropland and 5.B.2.2 Grassland converted to Cropland (N_2O emissions from disturbance associated to land-use conversion from 5.B.2.6. Other Land converted to Cropland was also reported in the previous submission. But it was reallocated into the 5.B.1 Cropland remaining Cropland category and hence N_2O emissions are not reported.) The N_2O emissions are calculated from the obtained carbon stock change in mineral soils, with the IPCC default values, using Equation 3.3.14 and 3.3.15 in GPG for LULUCF (IPCC, 2003).
The emission from this category was 0.09 Gg N_2O in 2009.

7.8.4. Biomass burning (CRF sector 5(V))

In accordance with the Government Decree No. 21/2001(II.14), the on-site burning of living biomass is prohibited in Hungary, only, the burning of slash on Forest Land is excluded in the regulation. Therefore, the controlled burning of biomass is reported as “not occurring” for Hungary. In this category burning of slash and wildfires from Forest Land, Cropland and Grassland are reported. Emissions from wildfires in Cropland and Grassland categories are reported by Hungary for first time in the 2011 submission. The emissions from the biomass burning were overall 1.11 Gg CH_4 and 0.01 Gg N_2O in 2009.

Choice of method

The Tier 1 method, Equation 3.2.20 given by the GPG for LULUCF (IPCC, 2003) was used for the estimation as follows:

$$L_{fire}=A \bullet B \bullet C \bullet D \bullet 10^{-6}$$

Where:
L_{fire} =quantity of GHG released due to fire, tonnes of GHG
A = Are burnt, ha
B = mass of available fuel, kg d.m. ha^{-1}
C = combustion efficiency
D = emission factor g $(kg.d.m.)^{-1}$

Choice of activity data

Data on the areas affected by wildfires (A) derives from the statistics of the National Directorate General for Disaster Management. Data on the areas affected by wildfires has been collected since 1998, but in the system of data collection a methodological change has been introduced in 2007, therefore more details and complete data are available since then.
To avoid inconsistency arising from the methodological changes, data for the period 1998-

2007 had to be adjusted. For the period 1998-2007 the average of the areas affected by wildfires over the period 2007-2009 were adjusted to the trends before 2007. For the period 1985-1997 the average of the emissions since 1998 are reported, due to lack of data.

According to the GPG for LULUCF (IPCC, 2003) the mass of available fuel (B) was assumed to be 10 t d.m. ha^{-1} in Cropland, and 1.641 t d.m. ha^{-1} in Grassland. The mass of available fuel for Grassland was estimated as the aboveground biomass on Grassland according to the climate zones distribution from the Table 3.4.2 of the GPG for LULUCF (IPCC, 2003). (See also Chapter 7.3)
The combustion efficiency (C) was 0.5 in accordance with the GPG for LULUCF (IPCC, 2003).

Choice of emission factors

The emission factors (D) were taken from the Table 3.A.1.16 of the GPG for LULUCF (IPCC, 2003), the values are shown in Table 7.34.

***Table 7.34** Emission factors for biomass burning*

Gases	Emission Factors [g / (kg d.m.)$^{-1}$]	
	Cropland	Grassland
CH_4	5.5	3
N_2O	0.1	0.11

Source: Table 3.A.1.16 of GPG for LULUCF (IPCC, 2003)

7.9. Sector specific QA/QC and verification

Emissions/removals from mineral soils of agricultural lands are estimated by external experts on a contractual basis, and the GHG division of HMS is responsible for the QA/QC procedures. The division of tasks makes possible that different persons make the estimates of emissions and the QA/QC procedures. In addition, the new institutional arrangement for LULUCF inventory preparation means that institutes instead of individuals have become responsible for the inventory preparation.

The LULUCF QC measures are based on the General QC procedures (Tier 1) of GPG (IPCC, 2000), Chapter 8.

The activity data, methodology used and estimated emissions are checked as follows:

Activity data

- Methodological issues of data collections of the land-use/ land-cover data are archived
- The differences between the different land-use datasets are documented
- Consistency of the activity data is checked. In the case of inconsistency (methodological change in the data collection) the dataset are adjusted in consultation with the data provider.
- The data inputs are checked for the transcription errors
- The units of activity data and the transformation are checked in the calculation sheet throughout the emission calculation
- The consistence of the total area of Hungary is checked in the land-use change matrices and the CRF tables
- The activity data are checked with data from other sources, if it is possible.

Methodology

- The applied methodologies and emission factors are documented and are compared with the GPG (IPCC, 2003)

- The correctness of the equations and factors in the calculation sheet are checked
- The consistency of the applied methodology is checked through the time series

Emissions

- Reported emissions are checked for the transcription errors between the calculation sheet and the CRF tables
- Recalculations and reasons for recalculations are documented

7.10. Sector specific recalculation

Following the recommendations from the in-country review conducted in 2010 the classification of land areas has been reconsidered for the submission 2011. The ERT suggested to Hungary to reallocate Set-aside croplands and set-aside grasslands from the Other Land category into the Cropland and the Grassland category. Together with this reallocation other changes were made. The cropland and grassland areas were revised for the period 2001-2008 according to the preliminary data of the General Agricultural Survey. The revision arising from the new survey data resulted significant changes in the estimation of set-aside areas. It is especially true of the grasslands, which area decreased by 241.6 thousand hectares to that in 2008, as a result of the more detailed data collection.
Although emissions from Wetlands are not reported, the area and land-use changes on Wetlands have influence on the estimation of the other land-use changes. In the previous submission the area of Settlements and Wetlands were determined by the HLC85, CLC90, CLC2000 and CLC2006. The area of Wetlands peaked in 2000, although this peak was not strengthened by the land-use change databases. In the previous submission the land-use change data were adjusted to the net areas to eliminate this inconsistency. (It was assumed that the missing land-use conversion were inland inundation on set-aside agricultural areas.) For the submission 2011 Wetlands areas were recalculated, using the CLC2006 inventory and the land-use change databases. It was assumed, that the CLC2006 database is the most reliable among the land-cover inventories and the CLC-change databases have higher resolution than the land-cover inventories, therefore the areas in the certain years (1985, 1992 and 2000) were estimated from the calculated net changes. As a result of the new methodology, the peak in 2000 was eliminated, and the net changes in the three period corresponded to the land-use change databases. This new methodology for the estimation of Settlements and Wetland areas are more reliable than the previous one, but resulted in changes to the estimated set-aside cropland and set-aside grassland conversions, and thus in emissions relating to emissions from 5.B Cropland and 5.C Grassland for the period 1985-2009. Table 7.35 gives an overview of the reallocated areas.

Table 7.35 *Change in the reported areas by land-use categories*

Year	Cropland	Grassland	Wetlands	Settlements	Other Land	Total change
	Area (1,000 ha)					
1985	184	40	-8	3	-220	0
BY	180	47	-8	3	-223	0
1986	178	50	-8	3	-224	0
1987	177	51	-8	3	-224	1
1988	177	53	-8	3	-226	1
1989	174	55	-8	3	-224	1
1990	170	56	-8	3	-220	1
1991	193	82	-8	3	-270	1
1992	216	108	-8	3	-318	1
1993	259	119	-9	1	-369	1

Year	Cropland	Grassland	Wetlands	Settlements	Other Land	Total change
	Area (1,000 ha)					
1994	303	130	-10	0	-422	1
1995	345	140	-11	-2	-471	0
1996	386	150	-13	-4	-520	0
1997	426	160	-14	-6	-567	0
1998	467	170	-15	-7	-615	-1
1999	506	180	-17	-9	-661	-1
2000	544	189	-18	-10	-707	-2
2001	532	191	-15	-8	-702	-2
2002	516	193	-12	-7	-691	-2
2003	505	195	-9	-6	-687	-2
2004	492	197	-6	-4	-682	-2
2005	489	201	-3	-3	-687	-2
2006	475	204	0	-1	-680	-2
2007	461	201	3	0	-668	-3
2008	455	200	6	1	-665	-3

Note: as a result of a transcription error between the CRF Table and the calculation sheet in the submission 2010, the sum of the total changes differs from 0. The transcription error has been already corrected for this submission.

Figure 7.10 provides an overview of the effect of the reallocation of the set-aside croplands and grasslands from the 5.F Other Land category into the 5.B Cropland and 5.C Grassland category. (Change in 5.F Other Land is shown as minus change.) In the period 1985-2004 the reallocation is the main driver of the change in the reported emissions from the 5.B and 5.C sectors, while the adjustment of the agricultural areas cause more significant changes after 2004 in the reported emissions. The difference between the curves in the period 1985-2004 is the effect of the adjusted set-aside areas due to adjustment of the Wetland and Settlements areas and conversions. After 2004 the effect of the revision of the croplands and grasslands area arising from the General Agricultural Survey has higher influence on the change of the CO2 emissions, than the reallocation.

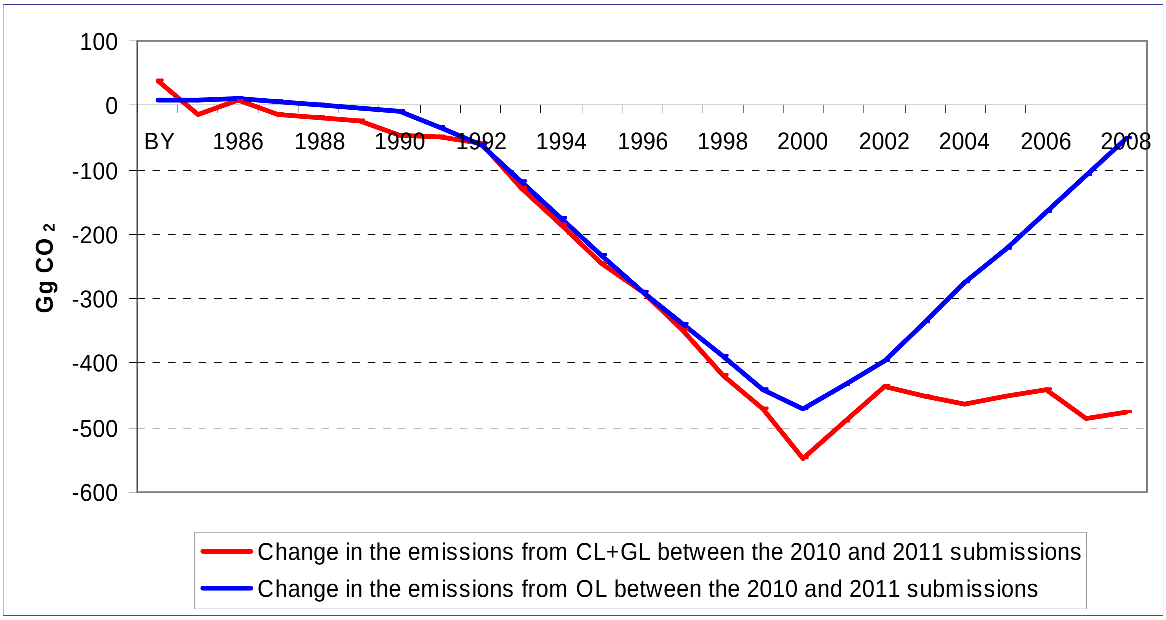

Figure 7.10 Effect of the reallocation of set-aside areas on the reported CO_2 emissions in the CRF Tables 5.B and 5.C

Note: Change in the emissions from OL are shown as minus change

7.11. Sector specific planned improvements

Development of country-specific values for the reference carbon stocks of mineral soils.

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8. Waste (CRF sector 6.)

8.1. Overview of sector

This section discusses the emissions from municipal solid waste disposal (CH_4), municipal and industrial wastewater treatment (CH_4 and N_2O) and municipal waste incineration (CO_2, CH_4, and N_2O). One peculiarity of the sector is that a part of the carbon-dioxide emissions is generated from biological (biogenic) sources and this CO_2 emissions are either reported as carbon stock change in the LULUCF sector or do not need to be accounted for (e.g. annual crops).

The major part of municipal solid wastes (MSW) is treated by managed disposal and a smaller part by reuse, incineration or other means. The average specific municipal household waste generation rate was 1.2 to 1.3 kg/capita/day recently. The total amount of MSW was 4,502 Gg in 2009. Out of this 4,502 Gg MSW, 748 Gg (17%) was recovered by recycling and composting, 431 Gg (10%) was incinerated for energy purposes, 3,247 Gg (72%) went to landfills, and 76 Gg (2%) was treated in other ways. The latter processing (“other ways”) means mostly mechanical biological treatment (MBT) which produces a refuse-derived fuel that can be used in power plants and cement factories. (The emissions from this fuel are accounted for in the energy sector.)

The waste sector with 3,734.96 Gg CO_2 equivalent represented 5.6% of total national GHG emissions in 2009. In the base year, total GHG emissions from the waste sector amounted to 2,972.03 Gg CO_2 equivalent which accounted for 2.6% of total national GHG emissions. In contrast with other sectors, emissions from the waste sector showed significant increase from the base year (+25.7%). However, the growth of emissions seemed to be stopping in recent years, moreover, a reduction of 5.6% could be observed between 2005 and 2009. In all the years, the largest category was solid waste disposal on land, representing 80,1% in 2009, followed by wastewater handling (18.0%) and waste incineration (1.9%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade as it can be seen in Figure 8.1.

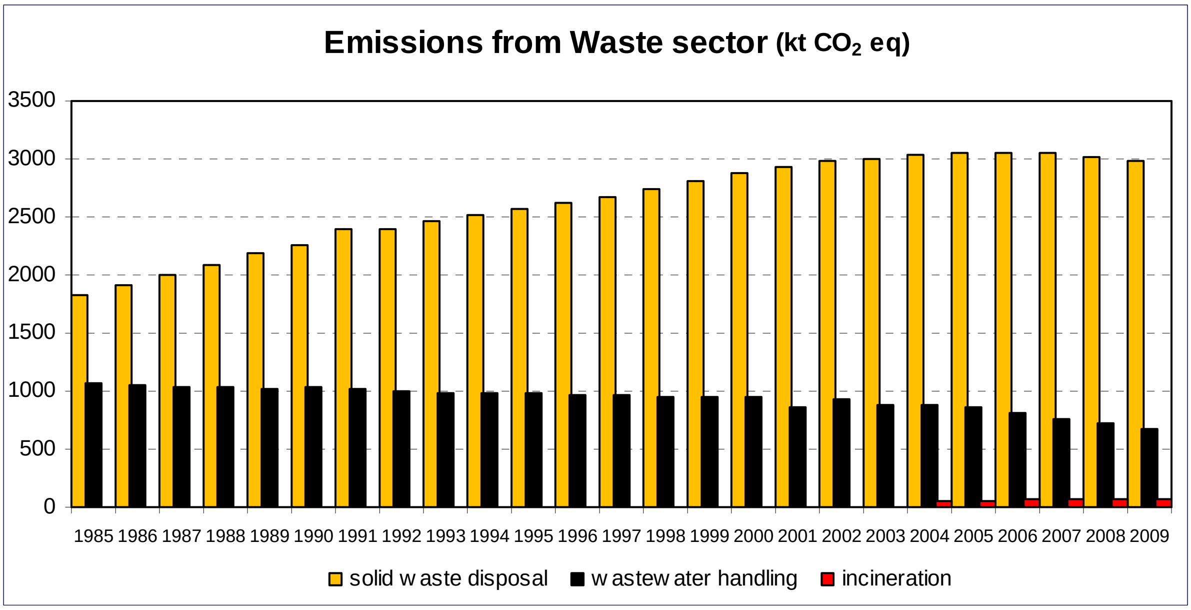


Figure 8.1. *The trend of emissions of the different categories in waste sector*

8.2. Solid waste disposal in landfills (CRF sector 6.A.)

Emitted gas: CH_4
Key source category: Level 1, 2; Trend 1, 2

8.2.1. Source category description

In case of managed disposal, the waste is disposed in landfills where it is compacted and covered. Under these circumstances, *anaerobic* degradation occurs, during which methane and carbon dioxide is emitted. In advanced disposal sites, the generated methane is recovered by incineration or flaring. Degradation requires several decades and occurs at varying rates. Since waste disposal is continuous, gas generation can also be considered continuous on a country scale.
The CO_2 generated in landfills is of biogenic origin and is thus excluded from the inventory. Under the conditions prevailing in landfills, CO_2 generated from wastes containing carbon of fossil origin is insignificant and direct incineration does not occur in landfills. Illegally disposed wastes are disposed in batches, in thin layers without compaction, in a fashion well-penetrable for oxygen. Therefore, degradation is aerobic and only carbon dioxide is produced. In accordance with the IPCC Guidelines, no CO_2 emission has to be included in this category.

8.2.2. Methodological issues

Emissions were calculated using a first order decay methodology, as response to the recommendations of the ERT in 2007. For the calculations, the IPCC Waste Model from the 2006 IPCC Guidelines was used. The FOD method produces a time-dependent emission profile which may better reflect the true pattern of the degradation process as it is claimed by the IPCC GPG.

Former inventories were based on a national method which can be described as follows. First, the fraction of organic compound was estimated based on official waste composition data. As the amount of the organic part of the waste, the quantities of the categories "paper", "decomposing organic" and the half of the amount of "textile" were taken into account. It was assumed that 250 l of biogas is emitted for every kg of organic waste. It was further assumed that half of the emitted biogas is methane and the other half is CO_2 where the latter has not to be taken into account. Knowing the density of methane the emission could be easily calculated. Recovery was subtracted. The national method is in a way similar to the IPCC Tier1 method based on the same assumption that all potential methane is released in the same year when the waste is disposed of. In 2007, for the purpose of comparison, the methane emissions were calculated with all these three methods (national method, IPCC Tier1 and FOD) for the entire times series, using the same background data. The IPCC Tier1 and our national method lead to similar results, the average difference was around 5%. At the same time, the FOD method gave significantly different estimates: in the base year, the calculated emission is only half of the value given by Tier1, and also for the last few years, the FOD estimates are around 15% less than the Tier1 estimates.

Formerly, as basic activity data the amount of removed municipal solid waste, which was published by the Hungarian Central Statistical Office in the Statistical Yearbook of Hungary and Environmental Statistical Yearbook of Hungary, were used. However, these publications do not contain this basic information any more, but make a reference to the *Waste Management Information System* maintained by the Ministry of Environment and Water. This database is a new development and contains very detailed information on waste management practices in Hungary. The Waste Management Information System can be accessed via internet as well. (http://terkep.kvvm.hu/hirweb/) Data availability has been improved significantly, at least for recent years.
(In the past, complete and obligatory data reporting on the collection of municipal solid waste did not

exist in Hungary and the published data were estimations partly based on representative surveys. During the initial part of the calculation period, the authority procedures for waste recording were not uniform. In this system, which was based on self-reporting (self-registering), data were processed at varying detail and quality levels due to the lack of legal and technical regulations related to individual waste types. In addition, an overall central registry of industrial waste was missing and the rules related to such wastes were not laid down in any legal instruments).

The FOD method requires a quite long time series. The default first year in the IPCC Waste Model is 1950. As the eldest data which can be found in statistical publications are for 1975, extrapolation had to be made. For this purpose, a similar pattern as in Figure 8.2 had been used. This figure was taken from a university textbook sponsored by the Ministry of Education and Culture.

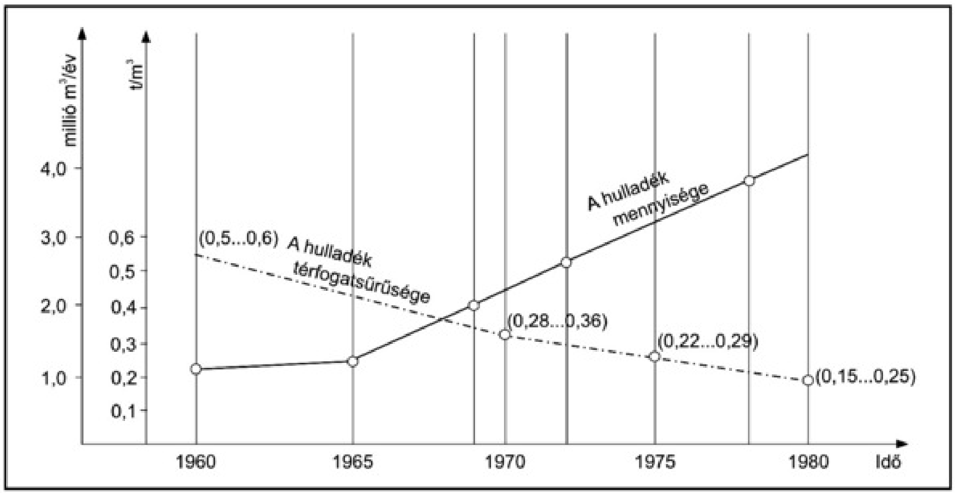


Figure 8.2. *The loosening trend of municipal solid waste in Budapest. The solid line denotes the amount of waste while the dotted line shows the decrease of volume-density. Source:* (http://www.hik.hu/tankonyvtar/site/books/b108/).

Before 2001, the amount of removed solid waste was reported in volume units (m^3), therefore these data had to be converted to mass unit using the gravimetric density (t/m^3) as an important physical characteristic of the waste. Between 1975 and 2000, the value of this parameter decreased from 0.3 t/m^3 to 0.2 t/m^3 based on the data of the Statistical Office. Both international and national studies suggested that the mass of municipal solid waste increased hardly while waste volumes increased drastically all over the world, which is reflected in decrease of the gravimetric density. These changes are attributable to the increasing amounts of paper and plastic in the packaging sector. In other words, this is the so-called loosening trend in MSW which can be seen clearly in Fig. 8.2. To summarize the above, the following densities were used for conversion from volume to waste units:

Table 8.1. *Waste densities used for conversion*

	1975-1985	From 1990	2000
Density (t/m^3)	0.3	0.22	0.2

As of 2001, data are collected and recorded in the more accurate mass units.

As regards *waste composition*, statistics only exist for the waste collected in Budapest and only from 1980. Having no other choice, these data were used for the entire country. For the FOD method the default values in the IPCC Waste Model were used for the year of 1950, but the measured values for 1980 and interpolation was carried out between these two years.
In the Hungarian statistics, the following waste composition categories have been used for a longer period of time: paper, plastic, textile, glass, metal, degradable organic, hazardous

waste, other non-organic. Recently, hygienic waste (e.g. nappies) has been added to the categories. These categories slightly differ from the requirements of the models, which had a minor impact on the selection of the parameters. Basically, the default values given in the IPCC 2006 Guidelines were chosen whenever possible. However, in the IPCC methodology the food and non-food (e.g. garden waste) fraction of the municipal solid waste are treated differently. As we have only one common category which is “degradable organic waste” that contains food and other organic waste as well, for the degradable organic carbon (DOC) content a value (0.16) between the default values representative for food (0.15) and for garden (0.2) were chosen.

Table 8.2. *Used DOC content of different MSW components*

	IPCC GPG	IPCC 2006 GL.	Used values
MCF	1.0	1.0	1.0
DOC of paper	0.4	0.4	0.4
DOC of textiles	0.4	0.24	0.24
DOC of food	0.15	0.15	0.16
DOC of sew. sludge	-	0.05	0.05
DOC of hygienic w.	-	0.24	0.24
DOC_F	0.77	0.5	0.5

Otherwise, default parameters of the IPCC waste model typical of dry temperate climate were used. The methane generation rate constants (k) were between 0.04 and 0.06 depending on waste type with an average value of 0.05. The default zero oxidation factor was kept, as well as the 50% fraction of methane in developed gas and the 6 month of delay time.

The amount of recovered CH_4 was calculated on the basis of energy production data obtained from the Energy Centre Hungary. These data in energy unit (TJ) were converted to mass unit as the amount of recovered methane by using the net calorific value from Table 1.2 in the 2006 IPCC Guidelines (Volume 2, Chapter 1), which is 50.4 TJ/Gg. It must be noted that the recovery data are not complete, further survey will be needed.

The following table summarizes our calculations.

Table 8.3. *Summary of activity data and the resulting emissions*

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1950	1800	22%	5%	30%			**0**	
1975	1872	19%	6%	30%			**58.9**	
Base year	**4018**	**19%**	**6%**	**28%**			**91.3**	**178.9**
1990	3963	20%	7%	32%			**107.8**	193.4
1991	3340	18%	3%	38%			**112.0**	156.2
1992	3506	19%	4%	39%			**114.5**	171.3
1993	3400	17%	7%	35%			**117.6**	157.9
1994	3571	18%	5%	33%			**119.8**	165.4
1995	3576	17%	4%	35%			**122.3**	160.3
1996	3788	19%	3%	32%			**124.5**	171.7
1997	4023	19%	6%	28%	4%		**127.0**	190.1

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1998	4067	18%	6%	31%	3%		**130.2**	194.7
1999	4146	20%	5%	31%	3%		**133.6**	203.1
2000	3847	14%	4%	41%	1%		**137.2**	167.2
2001	3821	16%	3%	41%	2%		**139.3**	175.8
2002	3907	16%	3%	31%	2%		**141.7**	163.1
2003	3966	16%	3%	30%	3%		**143.1**	160.1
2004	3978	15%	3%	31%	2%		**144.3**	166.7
2005	4072	15%	3%	29%	2%	0.0	**145.4**	165.1
2006	3902	16%	4%	24%	3%	0.9	**145.5**	152.0
2007	3477	11%	4%	25%	3%	1.7	**145.2**	111.4
2008	3494	13%	4%	24%	3%	1.7	**143.9**	121.5
2009	3439	12%	4%	24%	4%	2.4	**142.4**	120.4
Trend	**-14%**	**-36%**	**-25%**	**-15%**			**+56%**	**-32%**

8.2.3. Uncertainties and time-series consistency

Uncertainty can be estimated using Table 3.5 of the 2006 Guidelines. Accordingly, the following values were obtained:

Quantity of disposed municipal solid wastes	>±10%
Degradable organic carbon	±20%
Fraction of Degradable Organic Carbon Decomposed	±20%
CH_4 correction factor (=1)	-10 %,+0 %
CH_4 content of landfill gases (0.5)	±5%
CH_4 recovery	one order of magnitude
Half-life	±25%

The time series can be regarded as consistent.

8.2.4. QA/QC information

The compiler institute has now direct access to the Waste Management Information System maintained by the Ministry of Environment and Water. The calculations in the IPCC Waste Spreadsheet Model have been saved and archived for future reviews.

8.2.5. Recalculation

Following the in-county review, the times series of the annual MSW at the SWDS has been revised. With help of the experts of the ministry and the statistical office, some underestimations have been found and removed. Now, our new data are perfectly in line with the internationally published waste statistics for Hungary (e.g. EUROSTAT). The main cause of the discrepancies was the improved method of converting waste volume to waste mass for the years before 2001. This revision led to increase of emissions by 2-4%. Besides, minor inconsistencies between the CRF tables and the NIR were removed as suggested by the ERT.

8.2.6. Planned improvements

Following the recommendation of the ERT, we will seek for more justification of our assumption that illegally disposed waste does not lead to significant CH_4 emissions (ARR 95.). We expect more complete recovery data in the future, and we will search for waste composition data representative for other parts of the country (ARR 96.)

8.3. Wastewater treatment (CRF sector 6.B.)

Emitted gas: CH_4, N_2O
Key source: Level 1, 2, Trend 2.

8.3.1. Source category description

This sector covers emissions generated during municipal and industrial wastewater treatment. When the wastewater is treated anaerobically, methane is produced. Wastewater handling can also be a source of nitrous oxide, therefore N_2O emissions from human sewage are also part of the inventory.

8.3.2. Methodological issues

While estimating the methane emissions of wastewater handling, the key parameter is the fraction of wastewater treated anaerobically. However, complete and detailed data are not available for either municipal or industrial wastewater treatment. Therefore, methane emissions from wastewater treatment were calculated using the basic data available for us and the specific emission factors recommended by the 2006 IPCC Guidelines. Some wastewater data (COD values for the industrial sector, proportion of different treatment methods) based on measurements conducted by the authorities and emitters were obtained from the regional inspectorates for environment, nature and water. Besides, we consulted with experts, visited a few wastewater plants and checked the calculations of the neighboring countries as well.
For domestic wastewater, the activity data - the quantity of total organic waste (TOW) - was calculated by multiplying the population of the country by the IPCC default value of Biochemical Oxygen Demand that is BOD_5 = 60 g/person/day (Table 6.4 in Volume 5 Chapter 6 of the 2006 IPCC Guidelines). This default BOD value was confirmed by Hungarian experts of the Ministry of Environment and Water as well and was used uniformly for the entire times series and for the whole country.
The activity data for industrial wastewater were the total output of wastewater [1000m^3/year] and the *emitted* total organic wastewater [kg COD/year] which were collected by the regional inspectorates and further processed by the Research Institute for Environmental and Water Management (VITUKI). However, limited data were available on the industrial wastewater generation in individual sectors, especially for the initial years of the calculation period. Therefore a few years ago, inter- and extrapolation were carried out using also the ratio of the total organic industrial wastewater [kg COD/year]) and the total quantity of wastewater which is known for 2000 (0.008976) and for 1987 (0.005555).
However, the used TOW data for industrial wastewater seemed not to be correct, especially if they were compared with the data of similar countries or data from the literature. Therefore in 2008 we started to use *COD values per wastewater output* as given in Table 6.9 in the 2006 Guidelines. Special emphasis was given to industries with high COD output, e.g. food and beverage, paper and pulp, chemical industry. The difference between the new and the formerly used activity data can be as big as an order of magnitude. The compiler institute expects to have direct access to the wastewater information system in the near future, therefore more detailed data will be available to refine the calculations.

For the calculation of the *emission factor* (EF), the default maximum CH_4 producing capacities of 0.25 kg CH_4/kg COD and 0.6 kg CH_4/kg BOD were used for industrial and domestic wastewater, respectively. The choice of a proper methane conversion factor (MCF) was somewhat more difficult. (Before 2007, a value of 1 for MCF was used as if all wastewater were treated anaerobically which was definitely not the case). To calculate the value of MCF, the following additional information was collected:

- Fraction of population with no connection to the public sewerage system (source: Hungarian Central Statistical Office;
- Fraction of total wastewater treated at least biologically (secondary treatment) (source: VITUKI)

Using these additional activity data, the following assumptions were made:
In accordance with the 2006 IPCC Guidelines, for people using septic systems or any other domestic means (no connection to public sewerage network), it can be assumed that half of the BOD settles, therefore MCF=0,5 was chosen. (Table 6.3 in the 2006 Guidelines). In the base year, the portion of population connected to public sewerage system was less than 40% now it's around 70%. It must be noted, however, that the percentage of dwellings connected to public sewerage network is still below the Central-European average. It is further estimated, based on a study from the year of 2002 that around 20% of the wastewater/sludge is collected from those domestic systems and taken to treatment plants. Newer data indicate that the share of collected wastewater from septic system is diminishing, therefore 5% was used for 2006-2007, and 0% for 2008 and 2009.
Usually, collected wastewater undergoes aerobic treatment in the plants. Still, MCF=0.15 was taken as the mean value between the values characteristic for well managed and overloaded aerobic treatment plants. (Table 6.3 in the 2006 Guidelines). Using this rather high value of MCF might have lead to a little overestimation of emissions, as the internal review of the EU pointed out. However, these emission estimates contain also the emissions from sludge treatment which would justify our choice for a higher value of MCF. For untreated and only mechanically treated wastewater zero MCF was used. In 2008, about 70% of municipal wastewater was treated at least biologically, while 5% was untreated and 25% mechanically treated, which is a great improvement. In 1997 only 56% of wastewater was subject to at least secondary treatment, and 40% was not treated at all.
Considering industrial wastewater, statistics show that only 20% of all wastewater output is treated at least biologically. However, this statistics relates to the volume of the wastewater. If treatment methods are analyzed on COD basis, it can be concluded that about half of the COD is treated at least biologically. The reason behind this difference is the quite large amount of wastewater output with low organic content from some industries, especially the iron and steel industry.
Not enough information is available on the sludge generated during wastewater treatment and on the distribution of the degrading fraction between the water and the sludge phases. Therefore, the emissions from most of the generated sludge were not calculated separately. Nevertheless, the emissions from deposited sludge in landfills are taken into account in the SWDS category. Based on the data from the Energy Centre Hungary, the amount of recovered methane was subtracted. The following table summarizes our results.

Table 8.4. *Summary of emission estimates from wastewater treatment*

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH_4	Emissions domestic wastewater [Gg CH_4]	Emissions industrial wastewater [Gg CH_4]
Base year	39%	55%	45%		38.85	*1.48*
1990	41%	50%	50%		37.42	*1.30*
1991	42%	50%	50%		37.26	*1.17*

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH_4	Emissions domestic wastewater [Gg CH_4]	Emissions industrial wastewater [Gg CH_4]
1992	42%	50%	50%		37.11	*1.06*
1993	42%	50%	50%		36.92	*0.96*
1994	43%	50%	50%		36.71	*0.87*
1995	43%	50%	50%		36.51	*1.05*
1996	43%	50%	50%		36.30	*1.22*
1997	45%	44%	56%		36.05	*1.07*
1998	47%	42%	58%		35.40	*1.05*
1999	49%	33%	67%		35.63	*0.94*
2000	50%	33%	67%		34.76	*0.90*
2001	52%	36%	64%	1.71	31.84	*0.68*
2002	55%	33%	67%	2.62	30.01	5.12
2003	58%	38%	62%	2.68	27.99	4.51
2004	61%	27%	73%	3.43	27.44	4.22
2005	64%	20%	80%	3.83	26.81	4.01
2006	66%	23%	77%	6.69	25.07	3.42
2007	68%	25%	75%	7.24	23.06	*3.42*
2008	71%	30%	70%	6.69	22.19	2.88
2009	72%	28%	72%	8.75	19.75	2.91
Trend					***-49%***	

As required, nitrous oxide emissions from domestic wastewater effluent were estimated using the IPCC default method and default parameters and emission factor. (Table 6.11 in 2006 Guidelines)
(Emission factor, (kg N_2O-N/kg –N) EF = 0.005, Fraction of nitrogen in protein (kg N/kg protein) F_{NPR} = 0.16 Factor to adjust for non-consumed protein: $F_{NON\text{-}CON}$ = 1.1; Factor to allow for co-discharge of industrial nitrogen into sewers: $F_{IND\text{-}COM}$ = 1.25)

Table 8.5. *Protein consumption and the resulting N_2O emissions*

	Protein consumption [g/capita/day]	**Nitrous oxide emission [Gg N_2O]**
Base year	100.0	0.67
1990	104.7	0.69
1995	95.0	0.62
2000	96.6	0.62
2001	93.9	0.60
2002	93.5	0.60
2003	103.0	0.66
2004	105.7	0.67
2005	105.4	0.67
2006	104.6	0.67
2007	101.3	0.64
2008	100.6	0.64
2009	*100.6*	*0.64*

8.3.3. Uncertainties and time-series consistency

Based on the above considerations, the uncertainty of the calculation of the emissions from household wastewater is relatively high. In the industrial sector, data became more reliable in the recent years as a result of the new reporting requirements. However, they do not cover all the emitters, although the most important wastewater emitting sectors are included.

Uncertainty of the emissions from household wastewater treatment:	
Per human populations	-5 % to +5 %
BOD/capita	-30 % to +30 %,
Maximum methane production capacity B_0	-30 % to +30 %
Uncertainty of the emissions from industrial wastewater treatment:	
Quantity of industrial wastewater:	-25 % to +25 %
Wastewater /unit of production COD/ unit of wastewater:	-50 % to +100 %
Maximum CH_4 production capacity B_o :	-30 % to + 30 %
Uncertainty of N_2O emissions	
Emission factor	order of 2
Per capita protein consumption	±10%
Used factors	±20%

Source: according to the recommendations of the Revised Guidelines and 2006 Guidelines, on the basis of expert estimates

The time series of emissions from domestic wastewater is most probably consistent but it needs further verification. The industrial wastewater emissions are re-estimated only for the period 2002-2006, therefore the entire time-series is not consistent.

8.3.4. QA/QC information

The data collected by the environmental authorities are checked by an independent institution (VITUKI) that further processes the data.

8.3.5. Recalculation

Minor changes in N_2O emissions occurred due to revision of protein consumption data.

8.3.6. Planned improvements

According to a recently adopted legal instrument, operators are obliged to supply detailed data provided the rate of emission exceeds 15 m^3/day or the wastewater contains hazardous substances. As a result, more detailed information is expected to become available later on. Consistency of the time-series has to be verified and in case of industrial wastewater it has to be established.

8.4. Waste incineration (CRF sector 6. C.)

Emitted gases: CO_2, CH_4, N_2O
Key source: none

8.4.1. Source category description

This subsector covers only emissions from thermal waste treatment without energy recovery (D10). In 2010, for the first time, emissions from waste incineration for energy purposes (R1) have been re-allocated to the energy sector. As a consequence, only 13 to 31 per cent of CO_2 emissions from all waste incineration remained in this source category between 2004 and 2008. Before 2004, only emissions from the Waste Incineration Works of Budapest were included in the inventory, therefore all the emissions were removed from here and re-allocated to the energy industries source-category.

During waste incineration, mainly CO_2 is emitted out of which only the fossil part contributes to the total emissions. (Biogenic CO_2 emissions were calculated as well but these were included only as memo items). Methane emissions, which were estimated for the first time, are insignificant and N_2O generation is also minimal.

8.4.2. Methodological issues

For estimating CO_2 emissions, the standard calculation method was used, i.e. equation 5.11 from the Good Practice Guidance (Ch. 5 Waste) was applied. The detailed Hungarian Waste Management Information System made it possible to disaggregate the activity data (amount of incinerated waste) into different waste types according to the European Waste Catalogue (EWC codes). It might be an interesting fact that 82 to 97 per cent of all incinerated waste in this source category was hazardous waste. Nevertheless, having these country-specific waste amount and composition data, the carbon content of the incinerated waste and the fossil (and negligible biogenic) fraction thereof could be determined by using default values from Table 2.5 and Table 2.6 in the 2006 Guidelines (Volume 5. Ch. 2). The following table summarizes our calculations.

Table 8.6. *Incinerated waste and CO_2 emissions from fossil origin*

	BY	1990	1995	2000	2004	2005	2006	2007	2008	2009
Incinerated waste (Gg)	NO	NO	NO	NO	54.07	46.56	68.90	65.06	63.66	69.87
Fossil fraction (%)	--	--	--	--	98%	96%	99%	92%	95%	89%
Fossil CO_2, Gg	--	--	--	--	52.19	46.98	69.93	64.05	64.12	68.17

The N_2O emissions were calculated using the default value for industrial waste from Table 5.6 in the 2006 Guidelines that is 100 g N_2O / t industrial waste. For the first time, CH_4 emissions were also estimated using an emission factor of 30 kg / TJ. For this purpose, the same mass to energy conversion factors were used as described in Ch. 3.2.6.5 of this inventory report. Both methane and nitrous oxide emissions are negligible.

8.4.3. Uncertainties and time-series consistency

Consistency of the time series needs to be investigated, as activity data start only in 2004.

8.4.4. QA/QC information

No source specific information.

8.4.5. Recalculation

No recalculation has been taking place.

9. OTHER (CRF sector 7.)

This sector is not in use.

10. RECALCULATIONS

10.1. Explanations and justifications for recalculations and their implications for emission levels and trends

Recalculation of some data-series of the inventory can be justified by several reasons. Just to name a few, QA/QC procedures, ERT recommendations, changing for higher Tier methodologies can lead to a recalculation. As a basic rule, whenever new information emerges that improves the quality or accuracy of the emission data, the emissions are recalculated. In addition to the recalculations, great emphasis was put on the determination of the Hungarian country-specific emission factors for the important technologies. All of these led to several recalculations of the inventories, thus the calculated values of the emissions changed accordingly. Since the details of those changes are described in the previous NIRs, this time we confine ourselves to the differences from the last submitted inventory.

10.1.1 Energy sector

10.1.1.1. Iron and steel production – Energy (and Industrial processes sectors)

During steel production iron oxide is reduced by carbon. The primary source of this carbon is coking coal. In the previous submissions emissions from coke were reported under the energy sector because of statistical reasons, but also CO_2 emissions were calculated in the industrial processes sector. In the latter case the emission was calculated knowing the carbon content's difference between iron and steel, however the original source of the carbon in iron was the reducing agent. To solve this double counting problem emissions from the 2.C.1.1 category was subtracted from emissions in the 1.AA.2.A category, emissions in the industrial processes sector did not change. *Figure 10.1* shows the results of these changes in the 1.AA.2.C category for the entire time-series.

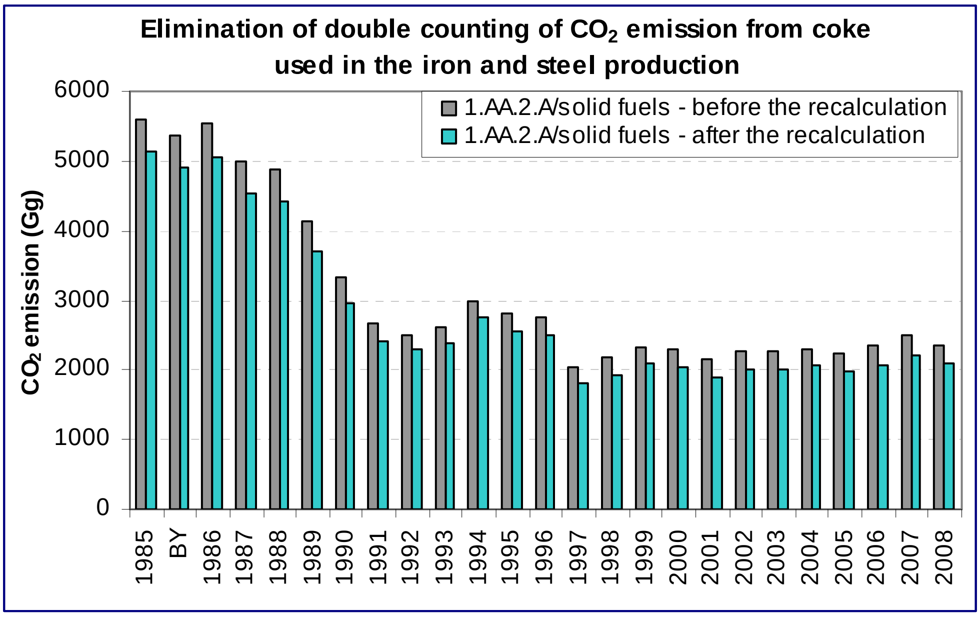


Figure 10.1. *Changes in the CO_2 emissions of 1.AA.2.A category due to the recalculation*

10.1.1.2. Combustion

Following the general guidance by the ERT, CH4 and N2O emission factors were changed to default values consistently. After the Saturday paper, changes were carried out only in cases which led to increase in emissions. For this submission, the work has been continued in the spirit of the Saturday paper. The overall effect can clearly be seen in Fig. 10.2.

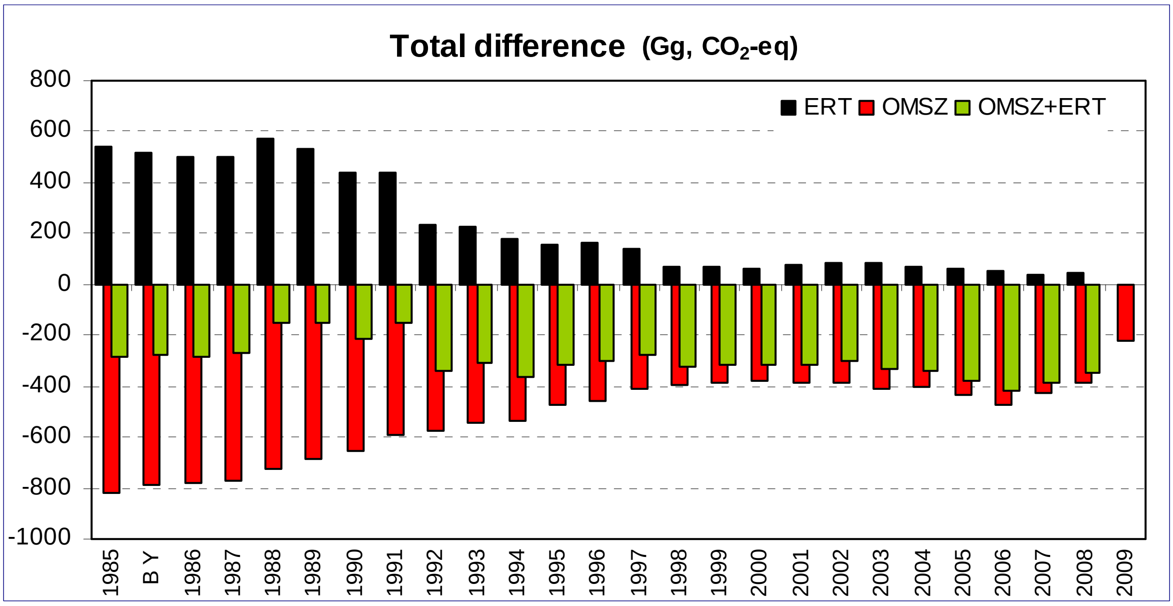


Figure 10.2. *Overall changes in emissions due to switching to default CH4 and N2O EFs ERT=following last years Saturday paper; OMSZ=further changes*

10.1.2 Industry

All recalculations in the industrial processes sector resulted in increase of emissions up to 5% (See Table 10.1). Details of recalculation can be found below.

Table 10.1 *Change in total GHG emissions from Industrial Processes sector*

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	Base year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
2010 submission	10,908.3	8,850.9	5,454.9	6,276.7	6,328.2	5,571.8	5,678.7	6,475.2	6,995.6	6,415.2	5,979.1	4,812.2
2011 submission	11,021.8	8,860.4	5,467.9	6,302.0	6,348.6	5,591.9	5,694.2	6,515.5	7,073.4	6,498.8	6,175.1	5,041.9
change (%)	1.04	0.11	0.24	0.40	0.32	0.36	0.27	0.62	1.11	1.30	3.28	4.77

10.1.2.1. Ammonia Production (CRF sector 2.B.1)

Correction of an error in the excel sheet between 1985 and 1990.

10.1.2.2. Nitric Acid Production (CRF sector 2.B.2)

Activity data have been updated for the period 2004-2007.

10.1.2.3. Carbon Black (CRF sector 2.B.5.1)

Following the recommendation from the in-country review 2010, CH_4 emission from carbon black production has been reviewed and the default factor has been applied.

10.1.2.4. 2.F. Consumption of Halocarbons and SF6 (CRF sector 2.F)

This year a comprehensive checking was carried out. All activity data has been verified and all calculations from the year 1992 has been updated. The calculation and copying errors were corrected. Besides, new data were added to 2.F.3 Fire Extinguishers sub-sector. This recalculation resulted in an increase of emissions, as shown in *Figure 10.3*.

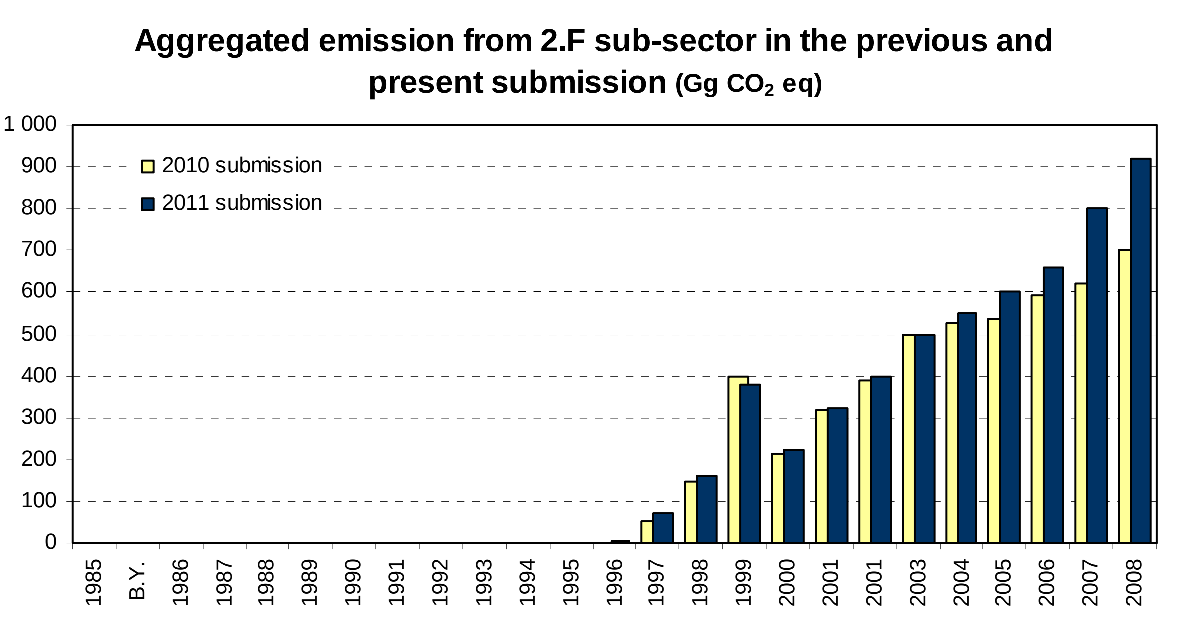


Figure 10.3. *Changes in 2.F. sub-sector (1985-2008)*

10.1.2.5. Aerosols/Metered Dose Inhalers/Other (CRF sector 2.F.4.2)

Activity data has been updated using data received from the factory.

10.1.3 Agriculture sector

The principal changes that resulted in recalculated estimations in 4.B Agriculture sector are as follows:

4.B Manure Management, CH_4

- Revision of CH_4 emission factors for poultry due to the modification of VS based on the Guidelines (IPCC, 2006) for all years 1985-2008.

4.B Manure Management, N_2O

- Revision to correct a calculation error of N excretion rate for dairy cattle for 2006-2008

4.D.1 Agricultural Soils, Direct N_2O-Emissions

- Minor revision of activity data in 4.D.1.2 Animal Manure Applied to Soils due to change in N excretion rate for dairy cattle for 2006-2008.
- Minor revision of activity data in 4.D.1.3 N-fixing crops due to filling the data gaps

in the datasets of harvested production for lucerne seed for 1996-2006 and for lentil, lupin and broad bean for 2006-2008.

- Minor revision of activity data in 4.D.1.4 Crop Residues due to filling the data gaps in the datasets of harvested production for meslin for 2006-2008.
- Revision of crop residue statistics in 4.D.1.3 N-fixing crops for 1985-2008.
- Revision of Residue to Crop Product Ratio for rice in 4.D.1.4 for 1985-2008.

4.D.2 Agricultural Soils, Direct N_2O-Emissions, Pasture, Range and Paddock Manure

- Minor revision of activity data due to change in N excretion rate for dairy cattle for 2006-2008

4.D.3. Agricultural Soils, Indirect N_2O-Emissions, Atmospheric Deposition, 2006-2008

- Minor revision of activity data in 4.D.3.1 Atmospheric Deposition and in 4.D.3.2 Nitrogen Leaching and Run-off due to change in N excretion rate for dairy cattle for 2006-2008

The net effect of the recalculations range in 0.2 to 0.6 percent with an average of 0.4 percent increase in emissions expressed in CO_2 equivalent. The smallest change (0.2%) refers to 1986 and the biggest one (0.6%) refers to 2004. Changes in methane emissions ranged from 0.4 to 1.8 percent with an average of 1.1 percent. Changes in nitrous-oxide emission ranged from 0.02 to 0.12 percent with an average of 0.08 percent. The net effect of recalculations is presented in the following Table:

Table 10.2 *Change in total GHG emissions from Agriculture sector due to recalculation 1985-2008(CO_2-eq)*

	1985	BY	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg]	17,511	17,403	17,517	17,612	17,100	16,491	14,501	11,718	
Submission 2011 [Gg]	17,550	17,449	17,552	17,647	17,144	16,539	14,555	11,765	
Difference [Gg]	39	46	35	35	44	49	54	46	
Percentage change	0.2%	0.3%	0.2%	0.2%	0.3%	0.3%	0.4%	0.4%	
	1992	1993	1994	1995	1996	1997	1998	1999	
Submission 2010 [Gg]	10,095	9,034	8,950	8,685	8,813	8,620	9,178	9,356	
Submission 2011 [Gg]	10,132	9,077	8,984	8,725	8,856	8,663	9,223	9,401	
Difference	37	43	34	40	43	43	46	45	
Percentage change	0.4%	0.5%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Submission 2010 [Gg]	9,075	9,310	9,449	9,220	9,322	8,804	8,846	8,906	8,783
Submission 2011 [Gg]	9,124	9,355	9,499	9,268	9,380	8,853	8,899	8,953	8,830
Difference	49	45	50	48	58	50	53	47	47

Percentage change	0.5%	0.5%	0.5%	0.5%	0.6%	0.6%	0.6%	0.5%	0.5%

10.1.4 LULUCF Sector

Following the recommendations from the in-country review conducted in 2010, the classification of land areas has been reconsidered. Set-aside croplands and set-aside grasslands has been reallocated from the Other Land category to the Cropland and the Grassland category, respectively. Together with this reallocation other minor changes were made to achieve more accurate, transparent and complete accounting of emissions/removals from the land-use conversions. Details of changes leading to recalculations are summarized below by land-use categories:

5.A Forest Land

- Calculation error relating to the area and the removal of the 5.A.2.1 Cropland converted to Forest Land in the base year.
- Inclusion of the previously not reported Non-CO_2 emissions from Wildfires in 5.A. 1 Forest Land remaining Forest Land for the period 1985-1998.

5.B Cropland

- Reallocation of emissions/removals from the 5.B.2.5 Other Land converted to Cropland and 5.F.2.2 Cropland converted to Other Land subcategories to the 5.B.1 Cropland remaining Cropland subcategory.
- Revision of cropland areas in line with the General Agricultural Survey (HCSO, 2010) for 2001-2008.
- Revision of area data by the CAO for 5.B.2.1 Forest Land converted to Cropland for 2005-2008.
- Inclusion of emissions from carbon stock change in dead organic matter in 5.B.2.1 Forest Land converted to Cropland sub-category for the years 1985-2008.
- Adjustment of set-aside agricultural areas (including set-aside croplands) arising from the adjustment of Wetland and Settlements areas and conversions for the period 1985-2008.
- Inclusion of CH_4 and N_2O emissions from wildfires in Cropland for the period 1985-2008.
- Omission of N_2O emissions from land disturbance associated to land-use conversion from Other Land converted to Cropland for the period 1985-2008. (In the previous submission the re-use of set-aside croplands for cropland were reported in this category.)

5.C Grassland

- Reallocation of emissions/removals from the 5.C.2.5 Other Land converted to Cropland and 5.F.2.3 Grassland converted to Other Land subcategories to the 5.C.1 Grassland remaining Grassland subcategory over the full time series.
- Revision of grassland areas in line with the General Agricultural Survey (HCSO, 2010) for 2001-2008.
- Correction of transcription error between calculation sheet and CRF Reporter Table 5.C.2.1 Forest Land converted to Grassland over the full time series.
- Adjustment of set-aside agricultural areas (including set-aside grasslands) arising from the adjustment of Wetland and Settlements areas and conversions over the full time series.
- Inclusion of previously unreported emissions from carbon stock change in dead organic matter in 5.C.2.1 Forest Land converted to Grassland sub-category for the years 1985-2008.
- Inclusion of previously unreported CH_4 and N_2O emissions from wildfires for the

period 1985-2008

5.E Settlements

- Minor adjustment of the area of Settlements over the full time series.
- Revision of area data by the CAO for 5.B.2.1 Forest Land converted to Settlements for the period 2005-2008.
- Inclusion of previously not reported emissions from carbon stock change in dead organic matter in 5.E.2.1 Forest Land converted to Grassland sub-category for the years 1985-2008. For more details see Chapter 7.2.
- Inclusion of previously unreported emissions from 5.E.2.2 Cropland converted to Settlements and 5.E.2.3 Grassland converted to Settlements over the full t.
- Correction of transcription error between calculation sheet and CRF Reporter Table 5.C.2.1 Forest Land converted to Settlements over the full time series.

5.F Other Land

- Reallocation of emissions/removals from the 5.F.2.2 Cropland converted to Other Land and 5.F.2.3 Grassland converted to Other Land subcategories to the 5.B.1 Cropland remaining Cropland and 5.C.1 Grassland remaining Grassland categories, respectively over the full time series.

5(III) N_2O emissions from disturbance associated with land-use conversion to Cropland.

- Correction of a calculation error related to 5.B.2.1 Forest Land converted to Cropland for 1985-2008 and revision of activity data for 2005-2008.
- Minor revision of area data in 5.B.2.2 Grassland converted to Cropland for 1985-2008.

The net effect of the recalculations is a decrease in the reported removals from the LULUCF sector for the period 1985-2003 and an increase after 2003 (Table 10.3). The changes in the removals range from -305 to 94 Gg CO_2 eq (relating to 2002 and 2008, respectively) with an average of 13 Gg CO_2 eq.

The changes can be explained by the change in CO_2 removals/emissions. The effect of the non-CO_2 emissions are negligible, ranging between -4 to 7 Gg CO_2 eq. The changes in the net removal due to the recalculation are higher in the period 2006-2008 due to the adjustment of the agricultural areas, which had the most significant effect in the recalculations conducted in 2011.

***Table 10.3** Change in total net removals from LULUCF sector due to recalculation in CO_2 equivalent*

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg]	-2,238	-86	-3,056	-3,475	-4,463	-3,674	-2,003	-2,300	
Submission 2011 [Gg]	-2,162	-50	-3,000	-3,435	-4,421	-3,629	-1,950	-2,252	
Difference	76	36	55	40	42	45	53	48	
Percentage change	-3.4%	-42.3%	-1.8%	-1.2%	-0.9%	-1.2%	-2.7%	-2.1%	
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	
Submission 2010 [Gg]	-3,373	-5,337	-5,805	-5,844	-1,930	-2,099	-3,122	-1,481	
Submission 2011 [Gg]	-3,320	-5,281	-5,749	-5,781	-1,865	-2,034	-3,064	-1,433	
Difference	53	56	56	62	65	65	58	49	
Percentage change	-1.6%	-1.1%	-1.0%	-1.1%	-3.4%	-3.1%	-1.9%	-3.3%	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**

Submission 2010 [Gg]	-422	-1,770	-1,000	-3,107	-2,122	-4,122	-2,162	-2,429	-3,629
Submission 2011 [Gg]	-364	-1,707	-906	-3,068	-2,129	-4,221	-2,289	-2,688	-3,933
Difference	59	62	94	39	-7	-99	-127	-260	-305
Percentage change	-13.9%	-3.5%	-9.4%	-1.2%	0.3%	2.4%	5.9%	10.7%	8.4%

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11. KP-LULUCF

11.1 General information

According to Decision 16/CMP.1, Parties to the Kyoto Protocol (KP) must submit information on land use, land use change and forestry (LULUCF) that is supplementary to what is contained in the report under the UNFCCC. This decision sets principles to govern the treatment of LULUCF activities; provides a common definition for terms such as “forest” and definitions for activities under Article 3.3 and agreed activities under Article 3.4; and provides modalities, rules and guidelines relating to the accounting of activities under Articles 3.3 and 3.4. Good practice guidance concerning the methodology for estimating GHG emissions and removals are given in Chapter 4 of the Good Practice Guidance on the LULUCF sector by the IPCC (2003).
Hungary started to report LULUCF-related information in its Initial Report under Article 7, paragraph 4, of the Kyoto Protocol (http://unfccc.int/files/national_reports/application/pdf/hungaryaareport_v4fin_c3.pdf) where, among others, Hungary reported the election of an activity under Art. 3.4, i.e. 3.4 Forest Management (FM), and broadly defined both FM and “forest”.
Hungary submits this part of her NIR as supplementary information based on the above legal documents. Information on forests not contained in this chapter can be found in Chapter 7 of the NIR. We submitted our first report with supplementary information under the Kyoto Protocol in 2010. Note that we have not received the report of the review of our first report under the KP until the date of this submission, so it was not possible to incorporate any comments or suggestions of the ERT.
Of all the possible options for the LULUCF sector under the KP, Hungary only elected FM under Art. 3.4. Thus, this part of the NIR mainly covers issues related to the forestry sector. Information on other land use related activities (e.g. cropland management) is limited to relevant information on land use conversions.

11.1.1 Definition of forest and any other criteria

As defined in her Initial Report, Hungary has chosen the following elements and single minimum values for „forest” (Table 11.1):

Table 11.1. Definition of “forest” with prescribed characteristics and the justification of the chosen value.

Characteristics	Chosen value	Justification
Single minimum land area	0.5 ha	identical with value reported to FAO earlier
Single minimum width of forest area	10 m	defined by the methodology of current forest inventory
A single minimum tree crown	30%	identical with value

cover value		reported to FAO earlier
A single minimum tree height value	5 meters	identical with value reported to FAO earlier

Concerning the **minimum size** of land area, it is the minimum size, by law, of forest stands. The mean size of stands is around four ha. There are also patches of forests in the country that are smaller than 0.5 ha, however, these patches are not surveyed currently.
Concerning **minimum width**, the chosen value occurs quite rarely, and the width of 10m allows for only 3-4 rows of trees.
Concerning **minimum crown cover**, the vast majority of the forests are on sites that allow for closed canopy closure already in young stands, and this closure is usually kept well above 50% until final harvest and regeneration. There are some stands in the country on sites where forests would not necessarily occur under natural conditions (and thus have low crown closure), however, the proper and intensive management of even these stands ensures that they would usually have more than 50% crown closure. None of these stands would be cultivated if the management of these stands were not profitable, which requires relatively high crown closure.
The above also holds true for **minimum tree height**. It only happens on very few extreme sites that trees cannot reach a mean height of five meters at maturity.

In addition to forestry aspects, the above elected definitions match those applied in the forest inventory and monitoring: the definition was elected also in order to attain the highest possible accuracy in the reporting. Moreover, the selected values are consistent with those reported to FAO and used in other international statistics.
The definition of “forest” under the KP is exactly the same as that under the UNFCCC.
Note, however, that additional information is also needed to define “forest” under the KP, e.g. *when* a certain piece of land becomes “forest” due to an afforestation or reforestation activity, and which areas are accounted for under FM. These additional pieces of information are detailed in the following sections as appropriate.

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

As stated both in our Initial Report, as well as above, Hungary only elected FM under Article 3, paragraph 4.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

Under the UNFCCC, emissions and removals from forests must be reported for “managed forests”. As reported in our NIR (Chapter 7), all forests can be regarded as “managed”. However, as discussed already in Chapter 7, some forests are classified as “found forests” (FF), i.e. forests that are identified in a particular reporting year (i.e. never before) and, in order that carbon stock change estimation is performed accurately, that cannot be included in Forest Land. The total area within the forestry sector under the KP can thus be divided into the following categories for each inventory year:

- AR: land under afforestation or reforestation since 1990
- D: land that has been deforested since 1990
- FM: all other forest land that was known to exist 31 December 1989 less D
- FF: found forest, which is the remaining part of the FL area in each inventory year, and which must be excluded from FM.

In the remaining parts of this section, first we define each activity below. The definitions are consistently applied throughout the period 1990-2009. The evolution of the area of the above categories except for FM is demonstrated in Figure 11.1. As shown below, the area of land under FM slightly decreases by D, and amounts to 1657 kha in 2009 which, as the area of D is small and rounding is applied, is the same as in 2008.

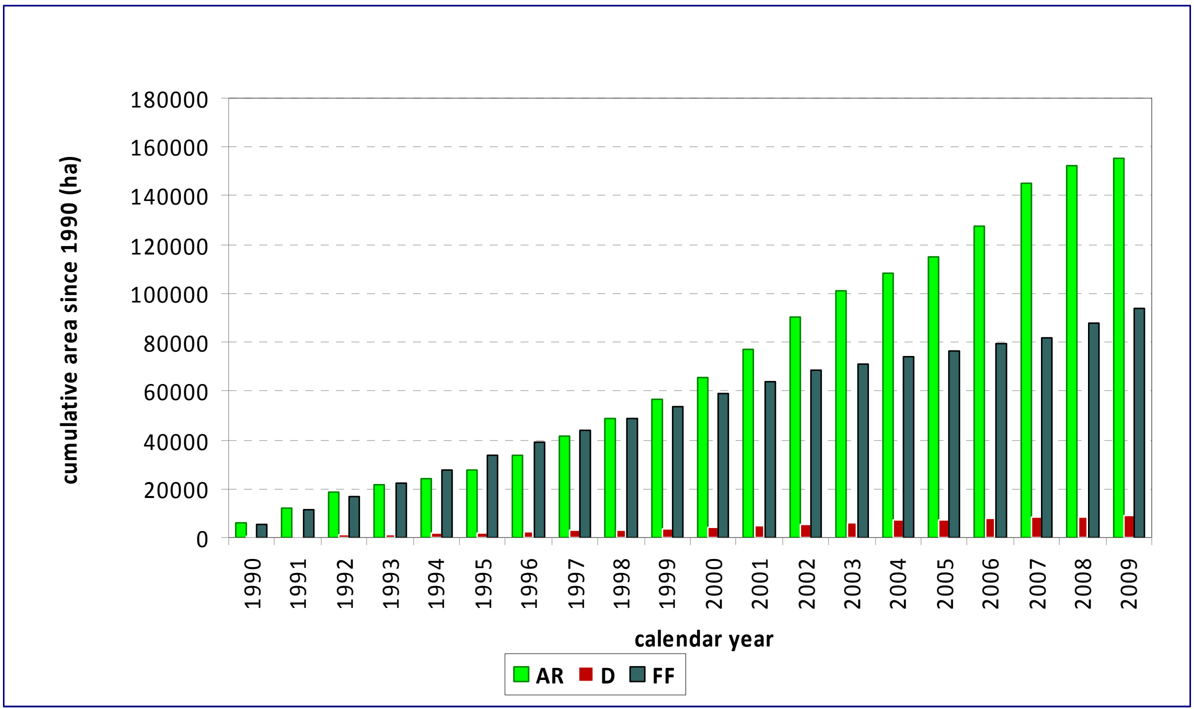


Figure 11.1. The evolution of the cumulative area of AR, D and FF between 1990-2008.

However, further specific information is required concerning how these categories may overlap, and how they are separated. This information along with the method of identifying land under the various KP activities will be provided under the subsequent headings in this section. Information on FF can be found both in Chapter 7 and in section 11.2.2. below.

Definition and identification of "AR since 1990"

AR in general is an activity that produces "forest", as it is defined above, on land that was not covered by such a "forest" before. The category "AR since 1990" includes all forest that has been established since 1990, and that has not been deforested (no AR land has been deforested in Hungary so far). However, this category can only include forest that can be demonstrated to have originated due to direct human induced activity. We thus include only areas here that can be demonstrated to have been established due to direct human activity.

In Hungary, afforestations are done in three steps. The first step is to do site preparation and, after this, to plant the propagation material in the area. The second step is a period of one to several years when the newly established stand is tended and beating-up is done if deemed necessary. Finally, the third and last step is when the afforestation is deemed "mature". At this point, the stand is inspected, and, if it is found to have established itself and is expected to be able to survive, grow and develop to a fully mature forest, it is regarded as a "certified forest" (and, under the UNFCCC, is moved to the FL-FL category). The whole process from site preparation to certification can last from one to 10-15 years, depending on species, site, weather and other factors, see Table 11.6. below.

It is noted that we began to identify “AR since 1990” areas by considering the database of the above certificates. However, we found that some of these areas (altogether some 173 kha since 1990) have not yet entered, or could not be identified in the NFD, which contains growing stock information, and which is used for the estimation of emissions and removals. Therefore, we only included the smaller of the two sets in the “AR since 1990” category, i.e. the one for which we have data in the NFD.

In relation to the KP, which sets a specific cut-off point (1 January 1990) in requesting countries to account for afforestations/reforestations, it is important to precisely define afforestations considering this cut-off point. In Hungary, in order to be conservative, “afforestations since 1990” are those, and only those, areas where both site preparation, as well as the planting of the propagation material started to happen after 1 January 1990. In general, site preparation and planting do occur in the same season anyway, shortly one after the other. As all areas where planting has occurred eventually become “forests”, they all enter the category “AR since 1990”.

It is also important to define the cut-off point after which an afforestation counts as an area “subject to 3.4 FM”. Indeed, due to provisions of the Forest Act, all afforestations become subjects to FM right away as they enter the AR category.

We note here that the category “AR since 1990” includes the areas of stands that were afforested, but not adjacent roads or other areas that are not covered by trees, see section 11.2.2. below.

Finally, we also note that the statistically captured forest area keeps increasing at a rate that is higher than the area of land under AR. This is explained later, however, it must be mentioned here that non-registered and illegal afforestations, as well as unregistered natural expansion of the forest are regarded as changes that do not comply with the definition of AR, therefore, these areas (called “found forests”) are excluded from the AR category.

Definition and identification of “D since 1990”

D areas are those that have been clearcut and removed from forest management in order that the area can be used for non-forestry purposes (i.e., for other land use).

It follows from the above that an area enters the D category right away, i.e. in the year, of the clearcut which was made in order that the area can be used for non-forestry purposes.

In Hungary, deforestations have not been done frequently since 1990 nor were they done before that. The location was of no importance for the forest inventory earlier, however, all deforestations have to be certified, and the exact location of most deforestations even prior to 1 January 2008 are known.

The total area of deforestations was established based on statistical data collection back to 1990 using the certificates of the deforestations. However, it was suspected that these certificates are fully available only since 2003. Therefore, another, sample-based study was made that indeed showed that the total area of the deforestations before 2003 that could be retrieved from the National Forestry Database, which contains data of forest stands, was higher than the one that could be developed from the hard copy files of the certificates. This means that in fact some certificates, thus, some deforestation areas could not be identified by only using the certificates. Therefore, the area established by the certificates before 2003 was multiplied by a factor of 1.18, which was established in the above study and was deemed representative for the whole country, to estimate the area of the total deforestations before 2003. We could thus establish a full time series data of deforestations since 1990 (Table 7.4 and Figure 11.1).

It is noted here that, just like with AR, D areas include the area of stands that have been deforested, and exclude areas outside of the stands, like roads, see section 11.2.2. below.

The demonstration that regenerated areas under FM are not accounted for as D can be found in section **11.4.2**.

Definition and identification of “FM since 1990”

The definition of “forest management” in Hungary is well described in the Forest Act. The relevant forest act that was mainly in effect for the period of 1990-2008 was passed by Parliament in 1996 (Act LIV of 1996 on Forests and the Protection of Forests, see at http://www.mgszh.gov.hu/data/cms/132/407/Act_LIV_of_1996_eng.doc). Article 7 of this Act stated that “For the purposes of this Act, forest management shall be qualified as the entire range of activities aimed at maintaining, guarding and protecting forests, ensuring their public function, increasing forest assets, and exercising the forest usufructs in accordance with the provisions of Article 2.” The relevant section of Article 2, in turn, reads: “Forests should be used and exploited in such a manner and at such a rate, which allows the prospects of management to endure also for future generations (hereinafter referred to as: sustainable forestry), so that the forests preserve their biological diversity, naturalness, fertility, ability to regenerate, viability, furthermore, that they satisfy the protective and economic needs in harmony with the requirements of society, and fill their role serving the purposes of nature conservation and environmental protection, health and welfare, tourism, research and education.” Note that a new forest act was passed (Act XXXVII of 2009 on Forests, Protection of Forests and Forest Management).

“Forest management” in general thus includes all kinds of activities in the forest from protecting forests through their economic utilization (of all kinds) to making use of a wide variety of social and ecological functions and services of the forests. All these activities require rather intensive management of all forests, although this intensity is quite different in the various stands depending on site, species, and the local objective of managing the stand. Managing forests involves preparing forest management plans, afforesting, regenerating, intensive thinning, harvesting, forest protection, road building, inspecting and others. The intensity of management is characterized by the length of the operational cycle of returning to each forest compartment (of about four ha in average as mentioned above), which varies from about a few weeks (in afforested or regenerated areas where tending in necessary) to a year (in young poplar stands for tending) to five years (between precommercial thinnings in young stands of fast growing species) to maximum 15-20 years (between thinnings in older stands of slow growing species). Forest management planning covers all forests, and forest management plans are made for 10(-12) years. That all forests (in the sense of the above “forest” definition) are managed in one way or another in Hungary is partly an economic and practical necessity because the country uses more wood a year than what it produces, and because the density of the population, which requires all kinds of products and services from the forests, is quite high (108 capita km^{-2}, KSH 2009).

We also note that there are practically no remnants of virgin forests, old growth forests or other primary forests in the country. There are some 70 so called forest reserves in the country. Forest operations in these reserves are limited to a so called protection zone (altogether about 8 kha), which makes up most of the area of these reserves, and which surrounds the so called core zone where no traditional operation is conducted in (altogether about 4 kha). However, there is usually some activity even within these core areas such as protection by fencing, wildlife management, forest protection, research and education, and tourism. All protected forests are also included in the so called “Natura 2000” protection network that involves various protection measures.

The above means that Hungary applies a broad definition of “Forest Management under Art. 3.4”.

We also note that as activities include preparing forest management plans for the majority of stands, surveying and inspecting stands regularly, and conducting various types of thinnings rather intensively etc., as well as that one or several of these activities do occur in each stand each year, all forests in Hungary are regarded as “managed since 1990”.

Land under the “FM since 1990” activity is identified by establishing FM in 31 December 1989 (which then equalled the total FL at that point) and then subtracting D areas in subsequent years. It also means that no land has been added to FM since 1989, thus, FF (that are also discussed in Chapter 7.2) are also excluded from FM.

It is finally also noted here that, just like for AR and D, we apply the total area of stands for FM, too, see section 11.2.2. below.

Separating AR from FM

As stated above, one or more years after the beginning of an afforestation, which depends on species and site fertility, all AR lands become “forest” from the viewpoint of the definition of “forest” under the KP. From a domestic administrative point of view, when an AR land becomes a “forest” under the Hungarian regulations, it right away becomes an area subject to FM. Thus, since the category “AR since 1990” includes all areas that have been afforested since 1990, these areas could also be regarded as 3.4 FM.

Double counting is avoided, and full consistency with the report under the UNFCCC is achieved, by not establishing FM from an “independent” data source, rather, by making sure that FM is equal to the difference of all forests (“FL” in the report under the UNFCCC) minus the total of the “AR since 1990” (see below) minus “D since 1990” minus “FF” (see below). In this way, AR since 1990 that would otherwise classify as FM is automatically excluded from FM.

Separating D from FM

This issue is covered under section **11.4.2.**

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

As Hungary only elected FM under Article 3.4, no precedence or hierarchy issues arise.

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The spatial assessment unit in Hungary is 1 ha. This is ensured by the forest inventory that includes information of stands as small as 0.5 ha, i.e. areas that are smaller than 1.0 ha. Individual stands that are larger than 0.5 ha are also mapped at a spatial assessment unit of around 0.5 ha.

11.2.2 Methodology used to develop the land transition matrix

Land transition matrix is developed the following way:

- Areas under annual AR activities are identified on a per stand basis each year, and the area of these stands are summed up.
- AR stands that are harvested and that are not harvested are also identified on a per stand basis as it is recorded in the National Forestry Database (NFD) if an AR stand is harvested or not.
- Areas under D activity are identified on a per stand basis each year, and the area of these stands are summed up.
- The total forest area at the end of each year (since 1990) is identified on the basis of the NFD that includes appropriate records for each known stand in the country.
- Land under FM was identified at 31 December 1989. FM area was then reduced by the area of the deforested stands, and was not increased in any inventory year since 1990.
- Both before, as well as in 2008 and 2009, all changes in the forest area were also identified that were not due to AR or D activities (i.e., FF).
- The above procedure is done for all geographical locations regions in the country, and is also summed up at the country level.
- The above procedure area ensures the consistency of land under all KP activities, as well as FL under the UNFCCC.

The land transition matrix is to be reported beginning with the inventory year of 2009. However, as activities under the KP are defined “since 1990”, land use changes must be tracked back to 1990. Also, land allocation has evolved since 1990, and changes of land use occurred that cannot readily be classified under any KP activity. We therefore identified all changes in the land use statistics and classified them so that, eventually, all land can be accounted for in the respective categories since 1990.

In order to demonstrate that the land use and land use change information as reported under the UNFCCC is consistent with information under the various activities under the KP, below is a summary of the method of establishing the area of FM with the relevant data at the country level.
It must be noted here that, as discussed in Chapter 7.2, we report the “Forest land” area in the CRF table under the UNFCCC. The reason for reporting this area is that it is only possible to account for all land area of the country in the CRF tables under the UNFCCC if this area is reported. Another data that we use and report is the total area of stands, or sub-compartments, which are included in the above “forest land” but that excludes areas outside of the stands such as roads. However, the area of stands includes areas within the stands that are occasionally not covered by trees. We use this area in the KP CRF tables because,

for statistical reasons, we only have this type of data for land under AR and D, and it would be impossible to fill in the land transition matrix (Table NIR 2. LAND TRANSITION MATRIX) of the KP CRF with the total area of forests under the various activities. However, the purpose of this matrix is to demonstrate changes between lands under the various KP activities, as well as other land, and the category “Other” is used to allocate non-stand areas. The same approach is applied to land under FM. Note also that the area of the AR and FM land in the Kyoto CRF tables do not match the total Forest Land area in the CRF tables under the UNFCCC also because we excluded the area of FF from the land under FM.

Many “forest area” statistics that are widely published in the country as official statistics include this, and often only this, type of area data.

The time series data of all the above forest area categories, along with that of the area type that is strictly covered by trees (“calculated area covered by trees”) is reported in Table 7.3 of the NIR.

Figure 11.2 below is a draft graphical representation of all changes in the area of all mandatory and elected activities under the KP (using the area of forest stands). These changes represent actual changes (for AR, D and FM) due to the activities under Articles 3.3 and 3.4 of the KP, but include those processes mentioned above that have resulted in the creation of the FF category.

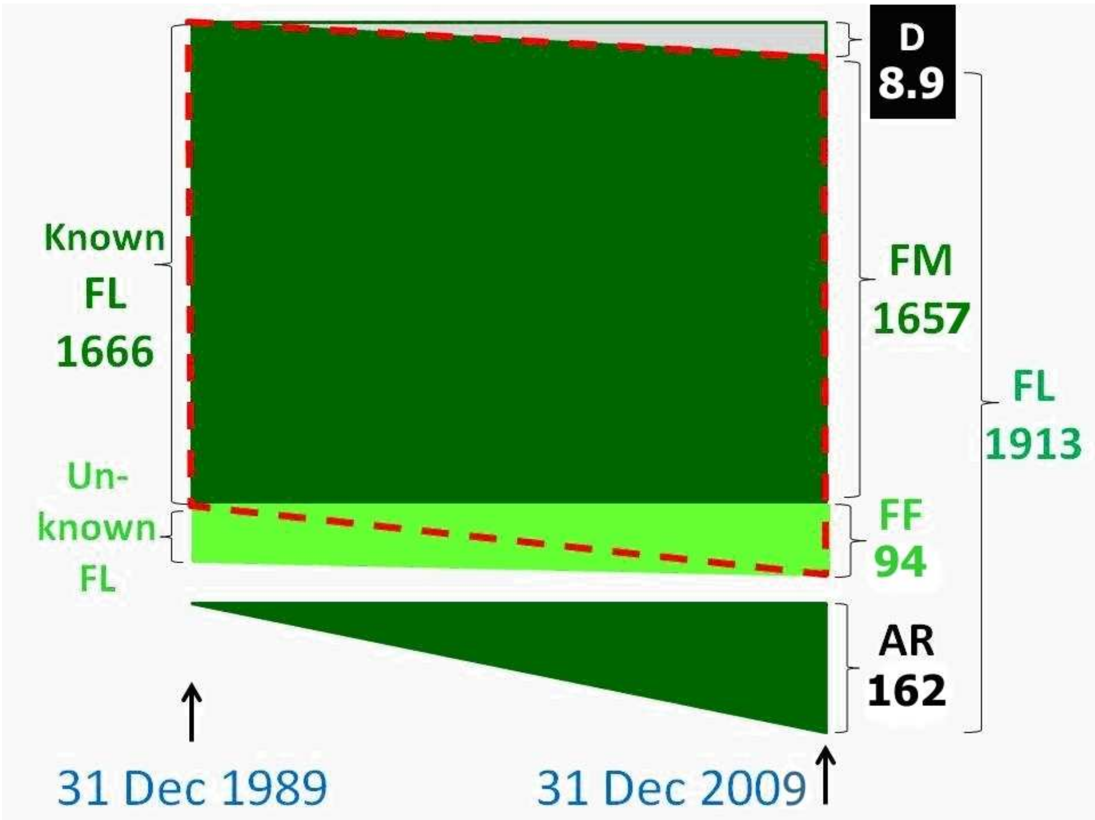


Figure 11.2. Graphical demonstration of changes in the area of the various activities under Articles 3.3 and 3.4 of the KP since 1990 (area in kha). The area denoted by the dashed lines is equal to the area identified by the NFD in each inventory year except for the AR area, i.e. the area of FM.+ that part of the FF that was identified up to the inventory year. Data under various activities are rounded-off area of sub-compartments in kha (they are slightly different from respective numbers elsewhere due to rounding-off). See text for other details.

Based on the definitions and the graph as outlined above, the areas of the sub-compartments under the Article 3.3 and 3.4 activities as of 31 December 2009 are derived the following way (only rounded numbers are used; for precise numbers, and for data by geographical locations, see the KP CRF table):

Forest Land 31 December 1989 = Known Forest Land 31 December 1989 = **1,665.6** kha

AR:

AR land 31 December 2007, since 1990 = **151.4** kha

New AR land in 2008 = **7.2** kha
New AR land in 2009 = **3.5** kha

Total AR land 31 December 2009 = 151.4 + 7.2 + 3.5 = **162.1** kha

D:

D land 31 December 2007, since 1990 = **8.1** kha

D land in 2008 = **0.3** kha
D land in 2009 = **0.5** kha

Total D land 31 December 2009 = 8.1 + 0.3 + 0.5 = **8.9** kha

FM:

FM land 31 December 1989 = **1665.6** kha

FM land 31 December 2008 = FM land 31 December 1989 - Total D land 31 December 2008
= 1665.6 – 8.4 = **1657.**2 kha
FM land 31 December 2009 = FM land 31 December 1989 - Total D land 31 December 2009
= 1665.6 – 8.9 = **1656.7** kha

Total changes accountable under the KP:

Total of above changes until 2007 = AR 2007 – D 2007 = 151.4 – 8.1 = **143.3** kha

Total of above changes until 2008 = AR 2008 – D 2008 = 158.6 – 8.4 = **150.2** kha

Total of above changes until 2009 = AR 2009 – D 2009 = 162.1 – 8.9 = **153.2** kha

***FF*:**

1990-2007: **82.0** kha

addition in 2008: **5.6** kha
addition in 2009: **6.5** kha

1990-2008 = 82.0 + 5.6 = **87.6** kha
1990-2008 = 82.0 + 5.6 + 6.5 = **94.1** kha

Checking:

Forest Land 31 December 2009 = Forest Land 31 December 1989 + Total accountable changes under the KP + Found forests = 1,665.6 + 153.2 + 94.1 = **1,912.9** kha
Forest Land 31 December 2009 = FM + AR + FF = 1,656.6 + 162.1 + 94.1 = **1,912.8** kha (the slight difference is due to rounding-off only)

The above calculation demonstrates that (1) all land is accounted for; (2) double counting is avoided; (3) all areas that are not in subcompartments, but are included in the “forestry area” (i.e., 2,039.4 - 1,912.9= 126,5 kha in 2009, see Table 7.3 of the NIR) are accounted for under “Other” of the KP CRF table (Table NIR 2. LAND TRANSITION MATRIX).

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Hungary applies Reporting Method 1 of the IPCC GPG for LULUCF (2003). This means that we identify regions for which we developed total areas under the various KP activities.

Two geographical locations are separated, and they are called North-Hungary and South Hungary (see Figure 11.3 below). These are geographical locations that are separated along the borders of municipalities (which in turn follow partly other administrative, partly natural borders), and that were found appropriate for this reporting. The identification codes used in the CRF tables are the following: North-Hungary, 1; South-Hungary, 2. „North” consist of the North Hungarian Mountains, the agglomeration of Budapest, the Transdanubian Mountains (north to the lake Balaton) and the Little Hungarian Plain. The Great Hungarian Plains and the Transdanubian Hills (south to the lake Balaton) belongs to „South”.

Both area and emission and removal data for the above geographical locations are derived from stand, or subcompartment, level data. The identification system of subcompartments is made up of three elements which are registered for every subcompartment. These elements are: the municipality (village, or town), the compartment (a larger piece of forest, e.g. a hillside or a valley) and subcompartment (which is part of a compartment). The subcompartment is the basic unit of forest management, its mean size being approximately 4-5 ha. The number of municipalities was 3166 in 1990 and 3183 in 2008, so the borders of the municipalities are considerably stable in time. (The borders of municipalities declared and mapped by the Institute of Geodesy, Cartography and Remote Sensing, FÖMI, Hungary). Since every subcompartment exactly belongs to a municipality, and municipalities are unambiguously mapped, the geographical locations can be developed.

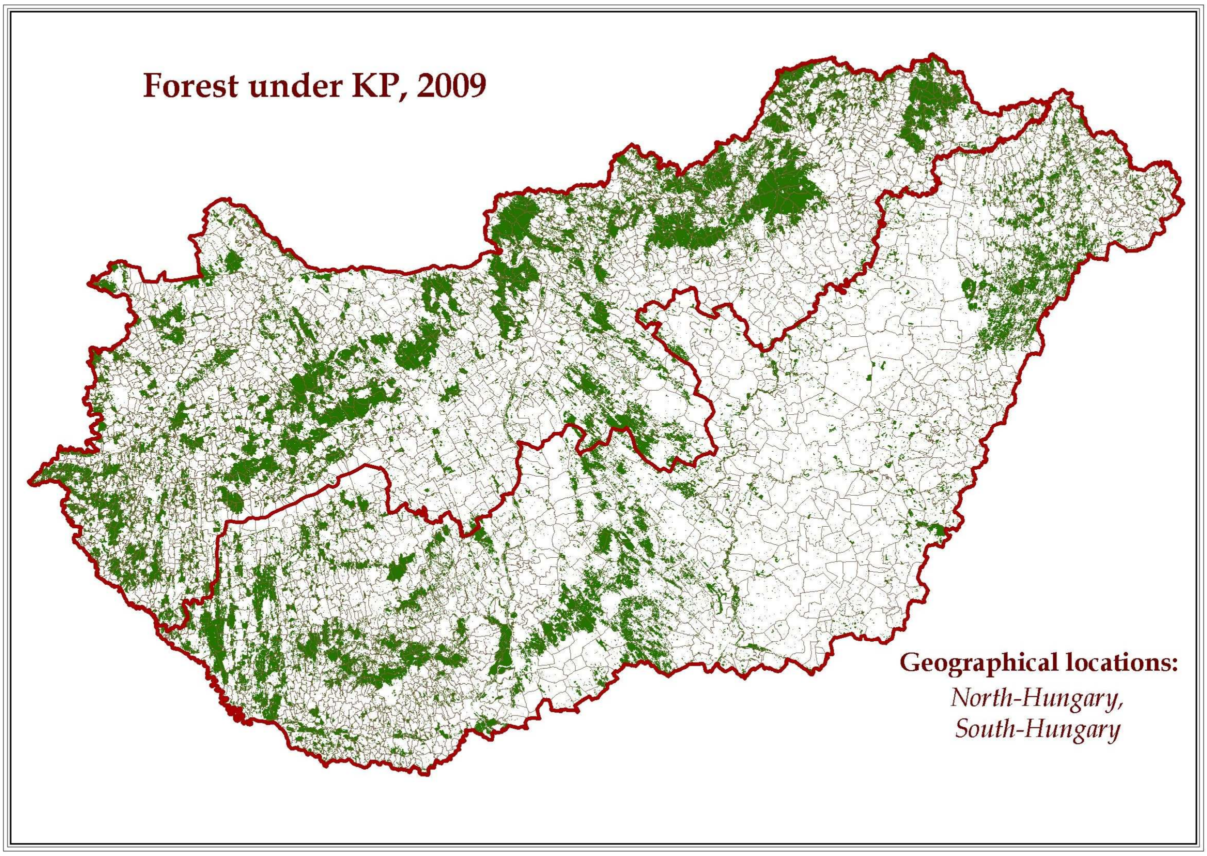


Figure 11.3. Map of Hungary with forests (green patches) and the border of the two geographical locations.

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1 Description of the methodologies and the underlying assumptions used

Definition of pools as applied in Hungary

The IPCC GPG for LULUCF defines carbon pools in a generic manner. In Hungary, pools are defined in a bit different, and more specific way to match them to available data in order that the estimation is as accurate as possible and practicable. These definitions are the same as in the NIR under the UNFCCC. In the estimations, we apply the following definitions:

<u>Above-ground biomass (AB)</u>: all biomass of living trees, including bark, branches, twigs and leaves, that can be found above the height of potential cutting of the stem by chainsaw. This height is usually a few cm above ground; only 1-2 cm for small trees (e.g. at thinning age), and 5-10 cm for bigger trees, and can be 10-20 cm for trees of the age of final harvest.

<u>Below-ground biomass (BB)</u>: all living parts of the living trees below that above-mentioned potential cutting height. These parts thus include the stump, coarse roots and fine roots.

<u>Litter (LI)</u>: all dead plant mass, weather above-ground or below-ground, that is smaller than around 10 cm in diameter (in case of branches and roots). Note that as no quantitative

measurement of the change of the litter has been attempted, this 10 cm in diameter is just a theoretical value of currently no practical importance.

Deadwood (DW): all dead plant mass that is not litter (i.e., above the 10 cm threshold for standing and lying dead trees, and above the threshold of 20 cm for stumps).

Soil (SO): includes the organic carbon in the topsoil down to a depth of 30 cm. Inorganic carbon, as well as organic carbon in the below-ground deadwood and litter pools are excluded, but organic carbon in the organic topsoil layer is included.

General methodological notes

The emissions and removals on land under AR and D are different from those under the various categories under the UNFCCC, i.e., “Land converted to forest land” and “Forest land converted to other land”. Therefore, these emissions and removals must be estimated using specific procedures. All procedures are accurate as far as practicable.

The procedures are pool-dependent in the case of Hungary. As it is detailed later, Hungary directly estimates emissions and removals in the above-ground and below-ground biomass pools for AR, D and FM, and emissions from soils and DOM for D, however, it only demonstrates that the deadwood, litter, and soil pools are not a source for the aggregated forest area (i.e., AR and FM). Thus, Hungary’s report is complete as it covers all carbon pools, and also complete as it covers each activity under the KP.

With regard to the processes that may bring about changes in the carbon pools, the report can also be considered as complete. The carbon stock changes in the biomass pool are estimated using the stock change method (in a similar fashion than for categories under the UNFCCC), which automatically ensures that all processes, i.e. all changes due to growth and all changes due to loss (i.e., harvest, natural disturbances like fires etc.) are taken into account. With respect to the pools where demonstration is applied, all major processes are also considered (see below).

For the biomass pools, the estimation of emissions and removals in lands under the AR and D activities are directly estimated from the carbon stocks of consecutive calendar years (for AR), i.e. from carbon stocks as of 31 December 2007 and those as of 31 December 2008, and of the inventory year of 2008 (for D). (Carbon stocks of land that is deforested in 2009 is taken 0 at the end of 2009.)
These carbon stocks are calculated from stand level volume stocks of each stand under the various activities using the equation in section 7.2.1 of the NIR (which is basically a modified form of the relevant equations in the IPCC, 2003, GPG). This implies that it is assumed that there is no biomass, deadwood or litter in the afforested land before the afforestation. This is justified as most afforested lands are abandoned croplands and abandoned grasslands where it takes substantial time for a natural vegetation to establish perennial vegetation of substantial biomass. To estimate growing stock in the afforested areas, empirical yield tables and local (ground-based) field measurements are used for the appropriate combinations of species and site conditions as a component of the national forest inventory that is described in Chapter 7.2.

Other parameters of the equation are also as detailed in section 7.2.1. However, we note that the same root-to-shoot value of 0.25 is assumed for stands of land under AR, which can be regarded as rather conservative because young trees usually have higher root-to-shoot ratios than mature trees. This assumption leads to an underestimation of removals on AR land.

It must be noted here that the forest inventory is designed to provide information on the actual situation of stands in each year. This means that carbon stocks in each year can be derived from stand-level information for some but not all AR, D, L-FL for the GHG inventory under the UNFCCC, and for all forests (i.e., FL). However, the borders of the stands often change due to reasons of ownership of changes of professional standards, and it is not possible to keep track of most of these changes at the stand level. This involves that the carbon stock changes cannot always be estimated bottom-up from the stand level, rather, they can only be calculated at an aggregate level (i.e., at the level of geographical locations or categories).

The emissions and removals for lands under FM are indirectly estimated. This is done in order that the estimates under the UNFCCC and under the KP are consistent, that carbon stock changes are neither underestimated nor overestimated, and that double counting is avoided. With this approach, total net removals (NR) for FM are calculated using NR of FL under the UNFCCC, NR on land under AR and NE (net emissions) on deforested land according to the following equation:

Total NR of forests under FM in 2009 = Total NR of FL-FL in 2009 + Total NR of L-FL in 2009 – NR of AR in 2009 – NR of FF 1990-2008 in 2009

At the country level in Gg CO_2:

Total NR of forests under FM = -3,077 + (-139) – (-1,154) – (-147) = -1,915 (slightly different from the numbers in the CRF table, only due to rounding-off).

In this calculation we take the same specific carbon stock changes for FF that can be calculated for the entire forest area, which is 1.68 $GgCO_2$/kha for 2009. That the same value can be used is justified by the similar distribution of the FF and the entire forest land by species, age and site.

For biomass, the methods of the forest inventory are by and large the same that are described in the NIR under the UNFCCC. These methods are regarded as very detailed, and that are capable of even capturing all emissions from deforestations.

For the non-biomass pools, different approaches are taken for D, and for the other activities.

On D lands, we assume that, in the year of the deforestation, all above-ground and below-ground biomass, as well as DW and LI is completely removed from the area, i.e. carbon in these pools are emitted in the year of the deforestation.

On the other hand, soil carbon loss that is due to the total carbon stock changes from forest to non-forest is estimated. The procedure and the estimated values can be found in section 7.2.3 and in Table 7.9, respectively.

Finally, it is assumed that neither biomass, nor deadwood or litter is produced any more in D areas after the conversion, thus, no removals are accounted for.

For AR and FM, the option of paragraph 21 of decision 16/CPM.1. is selected for the non-biomass pools, and it is demonstrated (see below) that these pools are not a source, and no accounting is made for these pools.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

For FM and AR, Hungary does not explicitly quantify emissions and removals for three forest carbon pools, i.e. soil, deadwood and litter, but demonstrates that these pools are not a source. To demonstrate that soils are not a source, a conservative approach is taken that is based on the IPCC 2006GL methodology. The demonstration for DW and LI is based on expert judgment which is a practicable method in our situation (see below).

Demonstration for FM and AR that the soil organic carbon pool is not a source

This demonstration is necessary because, until this point, there has not been any soil carbon monitoring program in Hungary. However, we have used all available country-specific data and information for the below demonstration, thus, the demonstration includes Tier 2 elements.

In lack of country-wide direct measurements, information and data can best be used if the country is stratified (from a statistical point of view) in terms of processes that may bring about carbon stock changes. These processes are both natural, as well as direct human induced ones. Concerning these latter ones, they predominantly occur when forests are disturbed by harvesting or soil preparation. Therefore, forest land will first be stratified according to the main types of forest operations for which land area data is available. Then, a rate of emissions or removals will be assigned to the various strata. Finally, it will be shown that even if large emissions are assumed for strata of net emissions and small removals are assumed for strata of net removals, the overall carbon balance of the soils of the Hungarian forests is positive, i.e. removals are greater than emissions.

We note here that an earlier version of the procedure was earlier successfully demonstrated to experts in an international expert meeting (Somogyi, 2006).

The strata that are defined and separated in this demonstration are based on relevant KP activities and available country-specific data, and include two strata where afforestations and reforestations occurred since 1990, and three strata of the remaining forests (i.e. FM land excluding FF) where various other types of forestry operations take place or where no operations take place at all in the inventory year.

Afforestations and reforestations are in general areas where, depending on local conditions, soil preparation may take place, and of course planting or seeding always take place. These procedures may lead to carbon emissions. On the other hand, removals always occur in these areas due to the growth of the new vegetation. On balance, the areas may be net sinks or sources. Whether they are sinks or sources also depends on the time that has elapsed since the beginning of the afforestation.

In order to estimate the net carbon stock changes due to afforestations, two country-specific equations can be applied that specifically provide estimates of carbon stocks over time after the afforestation. The equations depend on whether the land that was afforested had earlier been *cropland* or *grassland*.

Below we first provide details on the strata that we identified together with methodologies of how carbon stock changes are estimated for them, then we provide a summary of total carbon stock changes by stratum and for the entire forest land under the KP.

<u>Afforested and reforested land since 1990 that was converted from cropland</u>

According to local case studies that were carried out earlier (Horváth, 2006, Somogyi, 2005), carbon is hardly ever lost from soils when cropland is converted to forest. From a theoretical point of view this is because cropland soils already contain low amounts of carbon (much lower than soils under forest vegetation), and even if some small carbon is lost it is quickly offset by the increase of soil carbon due to the fast growth of young trees.

This stratum will therefore be assumed to have an overall zero or positive carbon balance, and the amount of carbon that grows over time will be assumed to take place according to the equation for cropland by Horváth (2006). The original equation for cropland can be modified to directly estimate carbon stock changes over time, t, after the afforestation:

$$\Delta C_t = 43.5*(1-e^{-0.016*t})$$

The area of this stratum is calculated together with the area of the next stratum below.

Afforested and reforested land since 1990 that was converted from grassland

As opposed to the above case, converting grassland to forest is associated with a much more substantial disturbance as far as carbon emissions are concerned. This is mainly due to the fact that soils under grassland usually contain much more carbon that forests, thus, losses from the soil due to soil preparation, which may also be more intensive than on croplands, cannot be easily offset by the growth of forest vegetation. Indeed, a local study demonstrated that soil carbon is lost for decades after conversion (Horváth, 2006).

This stratum will therefore be assumed to have an overall emission for decades, and the change of carbon over time will be assumed to take place according to the equation for grassland by Horváth (2006). Again, the original equation for grassland is rearranged to directly estimate carbon stock changes over time, t, after the afforestation:

$$\Delta C_t = 32.9*(1-e^{-0.015*t}) – 29.0*(1-e^{-0.046*t})$$

The total area of all afforested and reforested land since 1990, as reported above, is 162,1 kha. The carbon balance of this area at any given time after 1990 depends on the relative amount of land that was cropland and that was grassland prior to the afforestation. There are no reliable estimates for the ratio of these two types of land for historic times, however, sample-based estimates were made for selected years to cover the 1990-2009 period for which we could identify land use prior to afforestations. The data shows a high share of cropland as a predominant land use before afforestations with a mean value of 81%, which corresponds to field experience and consensus of experts in the field.

In the estimation of the net removals by soils for 1990-2009, the AR time series data was split into two by the above share of cropland and grassland, and the above two equations were applied to the resulting areas.

The following strata are all parts of FM since 1990 that exclude those parts of forest land that were afforested or reforested since 1990 and that are classified as FF. These strata are defined by the forest operations that can be regarded as the most important from the point of view of emissions and removals.

Land under FM since 1990 where final cutting and artificial regeneration following professional standards occur

Artificial regeneration here means that a stand is replaced by a new one by applying operations that closely resemble those of conversions. These operations may include disturbances associated with final cutting and skidding of timber, soil preparation, erosion (on steep slopes), and planting or seeding. The amount of loss may depend on tree species, site and the technologies applied.

Currently, no country-specific data exists as to the extent of possible emissions associated with such regenerations. One way to estimate these emissions is to assume as if land were fully converted to cropland. This is obviously a huge overestimation as only a fraction of the carbon is lost when it is prepared for forest regeneration once, as opposed to consecutive and regular disturbance of the soil under cropland management. According to IPCC default factors (Table 7.12 of the NIR), if a forest land is converted to a full-till cropland without additional input of organic carbon (when forests are regenerated, no additional organic carbon input is applied), it loses some 18% of the original (i.e., reference) carbon stock.
With respect to the reference carbon stock, we assume the mean value (Table 11.2) that results from classification of the area by climate type and soil type, and from applying IPCC default soil carbon stock values (IPCC, 2006, see section 7.3 for details).

Table 11.2. Distribution and carbon stock of forest soils in Hungary by climate and soil types (for details, see section 7.3).

	WD HAC	CD HAC	WD sandy	CD sandy	Total
Distribution by percent	35.71%	53.59%	0.86%	9.85%	100.00%
SOC_{ref} (tC/ha)	38	50	19	34	**43.87**

The overall loss is equivalent to 43.9*0.18 = 7.9 $tCha^{-1}$. We use a smaller, but still very high value of 6 $tCha^{-1}$ for the specific carbon loss for this stratum. The emission estimated this way is assumed to take place in the year of the start of the regeneration, i.e. the above specific value is applied to the total area of the harvested forests in the inventory year. (This is equivalent to assuming that, using a 20-year-long default period during which all carbon stock changes take place, $1/20^{th}$ of the emissions occur from regenerations in the inventory year, $1/20^{th}$ of the emissions originate from lands that were regenerated the previous year etc.)

The area of this stratum is registered each year and is included in the statistics of the NFD.

We note here that these statistics are for the entire forest area, and may include some forests of the FF category, thus, a bit smaller area should be considered here. However, as we do not have statistics for FF in this regard, we apply the entire area in the calculations for the sake of conservativeness.

<u>Land under FM since 1990 where harvesting and natural regeneration is made following professional standards</u>

Natural regeneration here means that the area is regenerated through the propagation material that is locally produced by the trees of the mature stand. With a few exceptions when seeds or seedlings from elsewhere are planted under the mature stand, and which sometimes involves some, but not intensive soil preparation, this type of regeneration usually makes it unnecessary to do any soil preparation, and some small amounts of carbon may only be lost due to inevitable damages caused by removing timber from the area. However, this loss is assumed to be quickly offset by the growth of the dense new generation of trees, if not offset right away from the deadwood (mostly dead branches of harvested trees) and dead roots (of the same harvested trees) that is the result of harvesting the mature stand.

Because of the above, this stratum is assumed to have no overall emissions, i.e. a specific carbon loss of 0 $tCha^{-1}$.

As with the previous stratum, the area of this stratum is registered each year and is included in the statistics of the NFD.

All other land under FM since 1990 that are between regeneration and the beginning of the subsequent regeneration and final cutting (i.e. the stages of the above strata), and that may be affected by normal silvicultural operations such as thinnings

This stratum, by far the biggest one, includes all forests that cannot be classified into any of the previous categories. In these forests, the predominant process is the slow but steady growth of trees together with the associated slow but steady sequestration of carbon in the soil. These stands may occasionally and locally be disturbed by abiotic or biotic natural agents, or by thinnings, and some carbon is additionally lost due to natural decomposition of dead biomass. However, these disturbances generally only affect trees but not the soil, the roots of the cut trees slowly decompose and some of their parts become part of the soil, and the overall balance of all these processes is a net gain.

Therefore, these areas will be assumed to have a rather small but positive net carbon stock change per unit area. The assumed value is a net removal of 0.05 $tCha^{-1}$.

Concerning the area of this stratum, it is calculated from the total forest area under the KP minus the sum of all of the above strata, which is equivalent to the total FM area minus the area of the two other strata of the FM category

Emission and removal estimates for the various strata

Data for the above strata are found in Table 11.3. It is important to note that some of them come from scientific case studies (printed in bold), and some data are expert judgments (printed in italic) which, however, are conservative estimates in order to demonstrate that the sum of all values are negative, i.e. total removals are greater than total emissions.

The summary of all total data is thus a logical resultant of all data, and should only be regarded as a value of which only the sign is relevant and demonstrable. In other words, the total value is not regarded as an accurate estimate, and is not intended to be a basis for accounting, it is only intended to serve the demonstration of the correctness of the assumption that soils are not a source.

Table 11.3. Area, emission and removal data for the various Forest Land strata. See text for details.

Forest Land Stratum under the KP	Estimated area in 2009 (kha)	Emission (+) and removal (-) factor ($tC\ ha^{-1}$)	Total emissions (+) or removals (-) (ktC)
Land under AR since 1990 that was converted from cropland	162.1*.81 = 131.3	indirectly estimated using Horváth, 2006, and corrected	-48
Land under AR since 1990 that was	162.1*.19 = 30.8		

converted from grassland		for 0-30 cm depth	
Land under FM since 1990 where final cutting and artificial regeneration is made following professional standards	15.4	*6*	92
Land under FM since 1990 where harvesting and natural regeneration is made following professional standards	3.8	*0*	0
All other land under FM since 1990 that are between regeneration and the beginning of the subsequent regeneration and final cutting, and that may be affected by normal silvicultural operations such as thinnings	1,656.6-15.4-3.8 = 1,637.4	*-0.05*	-82
Total		[-]	***-38<0***

We repeat that we selected the strata applied not only because they can match respective KP categories, but also because we have data, first of all but not exclusively area data, for these strata that are also relevant from the point of view of processes that result in emissions and removals. We additionally note other arguments why the above reasoning leads to highly conservative estimates, and therefore, highly certain conclusions that soils are not a source in lands under all KP activities:

- The equations by Horváth (2006) suggest a total annual net carbon removals of 62 thousand tC. However, we used the figure of 48 thousand tC in the above table for the first two strata because the estimates of Horváth (2006) are for the top 60 cm layer, and all other figures are for the top 30 cm only. However, it is well known that the majority of soil organic carbon can be found in the topsoil layer, and according to Table 4 of Hiederer (2009), the share of the SOC of the top 30 layer of all SOC in the top 100 cm of sampled forest soils (based on a fairly large sample) is, on average, 5.1/6.6, i.e. 77%, and 77% of 62 is 48.
- Concerning the value applied for artificially regenerated land, the assumed value of 7.9 $tCha^{-1}$ for the stratum of artificial regenerations is the absolute maximum that one could assume. However, even if regenerating (including tilling once) may mean high disturbance, no till certainly occurs continuously after the regeneration is done, which means that repeated emissions of ploughing are avoided in forests, thus, total carbon stock losses must be much smaller in forest land remaining forest land than converting a forest land to cropland. Even assuming emissions of 6 $tCha^{-1}$ seems to be a very high loss also given that there are many types of artificial regeneration applied, including ones that do not involve high-disturbance operations like ploughing. Currently, however, no statistics exist with respect to the share of the various regeneration types, moreover, according to experience, the operations leading to high emissions have been continuously replaced by less intensive ones (even due to economic reasons), and the specific emission estimate of 6 $tCha^{-1}$ is with high probability a rather high overestimation for the sake of the demonstration only.
- The average rotation age of those Hungarian forests that exclude the AR since 1990 and FF areas, and where no final cutting/regeneration occurred in 2008, is about (1,912-162-94) kha /19.2 kha = 86.2 years. Assuming an annual soil carbon stock increase of 0.05

$tCha^{-1}$ in these areas after regeneration is equivalent to assuming a total sequestration of 4,23 $tCha^{-1}$ for this total average rotation period, which is only about 70% of the emissions (6 tha^{-1}) that is assumed for these areas when they come to regeneration.

- This value of 0.05 $tCha^{-1}$ is a rather conservative estimate also if it is considered that the Horváth (2006) equation, which predicts a low rate of sequestration of after the age of 75, i.e. long after the afforestation, suggests that this lowest rate of increase (after the correction for the 30 cm soil depth as above), which may correspond to a rate in a "forest land remaining forest land", is about double of the 0.05 $tCha^{-1}$ rate.
- Finally, it is documented in many scientific publications that forests accumulate C in their soil. We selected a rather comprehensive study published recently by Berg et al. (2007) that states that "The amount of carbon sequestered in humus increases in forests and it appears that the average rate for Sweden is of the magnitude 100 to 200 kg C $ha^{-1}yr^{-1}$." (Note that this accumulation occurred in the humus layer of podsol soils, the depth of which never reached 12 cm.) Hungary is situated in a warmer region and has definitely higher tree growth rates, which involve higher ecosystem turnovers. Therefore, assuming a sequestration rate of 0.05 $tCha^{-1}yr^{-1}$, i.e. 50 kg C $ha^{–1}$ $yr^{–1}$, is a highly conservative approach. It is also conservative, because this rate decreases over time, but is by far the highest for decades after disturbance, which is the latest regenerations of these stands that used to be artificial one most of the cases in the previous decades.

All in all, by applying a method whereby all steps included conservative or even highly conservative estimates, we can conclude that the sum of all emissions and removals is negative, i.e., we demonstrated that the Hungarian forests are not a source. By applying conservative values, and demonstrating how and why they are conservative ones, leads to a high level of confidence in the conclusion.

Finally, once again, all the above is only meant to demonstrate that the Hungarian forests are not a source. The final result of the reasoning is not meant to be interpreted as an accurate scientific estimate of the rate of removals, or values used for accounting emissions or removals under the KP.

D DOM emissions

The Hungarian forest health monitoring system, called Forest Protection Network (FPN), supplied some data on deadwood in year 2010. Since it refers only to one year, we can not estimate the changes of DOM pools in other categories (FM, AR), however, the data available are suitable for estimating of the emissions from D for 1985-2009. The total emission of carbon from deadwood on a D land is always accounted for in the year of deforestation. The average amount of deadwood in all Hungarian forests was found to be 11.49 m3/ha, and this mean value is multiplied by the area of the deforestation to estimate the amount of wood from which CO2 is assumed to be emitted. The carbon stock changes are estimated from the above volume using the methodology of stock change as detailed above (and note that the average wood density that is applied for the woody biomass is a conservative assumption, i.e. it leads to an overestimation of DOM emissions).

The FPN network works as a 4×4km systematic sampling with concentrical permanent sample plots, and its 16x16km grid is part of the European level forest health monitoring Network (IPC Forest, Forest Focus, Life+ programs & FutMon Project).

Considering litter in D, we relie upon a case study published by Führer and Mátyás, who found that the average amount of carbon in litter is 3.2 t/ha, which amounts to some 1.5% of the whole carbon stock of Hungarian forests in general. (Note that the GPG suggests 28.2 t/ha as default for litter in mature warm temperate dry broadleaf forests, however, it is unrealistically high for the Hungarian forests that are, on average, neither mature nor natural.

The above average again was multiplied by the annual area of deforestation to develop emission estimates.

We note here that, because of the small scale of deforestations each year, and because LI and especially DW is a small carbon pool, this simple but anyway Tier 2 approach can be regarded as an accurate methodology as far as practicable.

Demonstration that the deadwood and litter carbon pools are not a source on AR and FM land

We currently do not have a monitoring that could provide accurate estimates for the amount of carbon stock or carbon stock change in the DW and LI pools on AR and FM land.

The below demonstration, which is in some respect a more detailed version of the assumption under the UNFCCC that the net emissions of these pools of all accounted forests (FM, AR, D) can be assumed to be zero, is based on some measurements, but mainly on sound scientific knowledge and reasoning.

AR land

When an area is afforested, first it is cleared of all above-ground biomass in case there was any, however, no DW and LI are usually present on these lands prior to afforestation. After afforestation, dead woody debris, litter as well as dead trees start to accumulate. In lack of representative measurements, the rate and timing of accumulation is not known, however, standard forestry experience suggests that they depend on species, site and silvicultural regime, and quickly accumulate over time. Fast growing species are usually planted so that no large amount of deadwood is produced, or thinned so that self-thinning does not ensue, but litter is continuously produced even in these stands. On the other hand, slow-growing species tend to produce dead wood and litter even at an early stage. Overall for all AR land, also considering that AR activity has been continuous since 1990, it can safely be concluded that the carbon in the deadwood and litter pools in AR lands was increasing in 2008 and 2009, i.e. these pools are not a source.

The above demonstration is based upon well-established principles of forest science, the every-day experiences of forestry practice, the experience and data of forest surveys, as well as sound reasoning. Because of this, although no representative measurements have been made as mentioned, the level of confidence of the demonstration is suggested to be very high.

FM land

No intensive monitoring of DW and LI exists in Hungary. However, data on standing deadwood (i.e., most of the deadwood) is collected in a 4x4 km sampling grid of the European-wide, so called IPC Forest monitoring network (this grid was established in the 1980’s, so almost all sampling points are found within the FM category). According to the most recent estimates, the amount of the standing deadwood has increased by just under 1% during the period 2000-2005 (Figure 12 of Somogyi-Zamolodchikov, 2007). As the cited figure suggests, this value is in about the mid-range of similar data for other European countries.

This empirical data is also supported by field experience. The silvicultural approach changed in the last two decades, and stands of indigenous species are managed much more along the lines of the close-to-nature forestry principles than on the lines of plantation forestry. This inevitably means leaving more deadwood in the forests than before, which concinuously increases the amount, and thus the carbon stock, of deadwood. The same obviously applies to litter.

As for AR, the above demonstration is based upon well-established principles of forest science, the every-day experiences of forestry practice, the experience and data of forest surveys, as well as sound reasoning. Because of this, although only measurements of low representativity have been made so far, the level of confidence of the demonstration is suggested to be high.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

According to the report of a rather recent IPCC meeting (Expert Meeting on Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions and Removals, 5-7 May 2009, Sao Paulo, Brazil), there are currently no scientifically sound methods to separate out indirect and natural GHG emissions and removal (IPCC, 2010). On the other hand, this is not necessarily needed if appropriate proxies are used. The above mentioned meeting, among others, stated that, although not perfect, the currently applied proxy, i.e. the so called “managed land” proxy is one that approximates the effects of direct human induced activities.

We also note that, especially for FM, this separation is taken care of by the various steps of the accounting, thus, no special separation is necessary, and we have indeed not have done any separation.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

See Chapter 7.2.6.

11.3.1.5 Uncertainty estimates

Uncertainties are associated with each step of the estimation of emissions and removals. Some of the uncertainties are already assessed above, and uncertainties are also covered to some extent in Chapter 7.2.4. Uncertainties are further assessed in a detailed procedure below.

It is underlined here, too, that it is due to the inherent uncertainties of our estimation procedure that we always take a conservative approach to avoid the underestimation of emissions and to minimize those sources of uncertainties that we are aware of. Thus, the most important aspect of uncertainty analysis is dealt with by applying the conservativeness principle. Another, by far not unimportant, aspect of dealing with uncertainties is to identify and quantify them. One principle in this identification and quantification is that we should first identify and quantify, and then prioritize uncertainties that could effectively be reduced by practicable policies and measures.

As for identification, we believe that the most important sources of uncertainties in the estimation of GHG emissions and removals due to the various KP activities include the following (the ones that are regarded less important are in brackets):

- identification of land under the various 3.3 and 3.4 activities over time
- growing stock and its changes

- basic wood density
- root-to-shoot ratio
- (carbon fraction of wood)
- carbon loss from soils, deadwood and litter due to forestry operations
- (forest fires and other disturbances within their normal, i.e. usual, range)
- forest fires and other disturbances outside their normal range.

We note here that the uncertainty of certain forest characteristics, e.g. the size of the area of land under the various activities, is unimportant in the process of estimating emissions and removals in our system because they do not directly enter the algorithm of the GHG estimation. Whether a land is identified or not, i.e. whether carbon stock changes on that land must be estimated or not, is, however, important, see the first bullet point above. In this respect, we believe that our data collection system results in an underestimation of removals and overestimation of emissions.

Also to be noted is that the above list is for both the country-level and the geographical location-level estimation, and certain elements of this list could be broken down to other elements, such as uncertainties of the steps of estimating wood volumes by stand etc. However, identifying uncertainties at these various sub-country levels would only be important if the uncertainty budget were developed from the uncertainties of these levels. We develop the uncertainties of the GHG inventory from the species level up, for which level we have estimated or assumed uncertainties.

With respect to measurements related to the biomass, the primary objective of the forest monitoring system in Hungary has been to obtain accurate information on the status and development of all forests in the country, and to assist forest management by developing forest management plans at the compartment and forest enterprise level. Thus, with respect to accuracy, the monitoring was designed to provide most accurate estimates at various aggregate levels. In addition, however, different levels of accuracy are applied to the individual sub-compartments depending on the age of the trees and the estimated amount and value (quality) of the growing stock. Due to needs for accurate emission and removal estimates from D, the monitoring system has been developed so that an accurate and detailed field survey is applied to areas to be deforested, thus, a fairly high accuracy has been achieved with respect to the biomass lost in deforestations.

Concerning the estimation of carbon stock changes on AR lands, it is noted that volume is estimated using yield tables, as well as ground surveys. Where the volume of the stand makes it practical to take field measurements, sampling and actual measurements are applied according to the forest monitoring protocol. The same way, where the growth of the stands is still slow and, due to the height of the trees and the thickness of the stand, it is simply impractical to take field measurements, the estimates of the yield tables are used. We note here that most increment and most harvests, i.e. most carbon stock changes occur in stands that were planted (5-)10-18 years ago, and where, because the resulting high growing stock, field measurements are often applied. That high growing stocks can occur even in such young forests is because of the typical structure of the afforestation program in Hungary by species, i.e., most afforestations have been done using fast growing species, which means that trees quickly grow into the age when, as mentioned, actual measurements are applied. Because of all the above, the emission and removal estimates for the AR lands can be regarded as accurate as far as practicable. Also, as mentioned before, a low root-to-shoot ratio is assumed for the AR, thus, below-ground biomass values are most probably underestimated.
In order to quantify the combined uncertainties of those factors in the biomass-related GHG emissions and removals that were not covered above or for which unknown uncertainties may still exist, a detailed study is demonstrated below using a Tier 3 level Monte Carlo analysis.

With respect to land identification, the soil, deadwood and litter pools, as well as non-CO_2 emissions from forest fires and disturbances, we refer to section 7.2.4 of the NIR and the above sections of Chapter 11. The analysis below thus only covers the above-ground biomass (AB) and below-ground biomass (BB) pools.

Finally, it is noted that the effect of carbon fraction of the wood will not be analyzed due to its known and rather small effect on GHG estimates, and also because no policy could currently affect this fraction anyway.

Methods

In order to analyse the possible effect of the uncertainties of selected factors that were mentioned above, a detailed Monte Carlo analysis was conducted for the emission and removals estimates of the AR land. We believe that GHG estimates for land under the D and FM activities, and those for the geographical locations we apply, have similar relative uncertainties due to the fact that the various factors affect the GHG estimates practically the same way (i.e. following the same physical/biological/ecological laws) in each land or geographical location, and the methods applied in both the forest inventory and the GHG inventory are also basically the same for FM, AR and D.

In order to identify possible levels of combined uncertainties in biomass carbon stock change estimates, the following procedure was conducted:

- As a first step, we assume that there is no overestimation, i.e. no positive bias for lower values in the estimation, of wood volume and wood volume increment. This is justified because there are some indications in the forest inventory that the traditional forest inventory underestimates wood volume and wood volume increment, but the rate of the underestimation is unknown yet.
- There are indications also in a sample-based inventory, which is not fully implemented yet, that trees are growing faster than before, i.e. faster than in the growth models we apply. On the other hand, a small fraction of stands may have started to grow slower due to adverse effects of climate change. Overall, it seems that growth rates are underestimated, but its rate is unknown.
- As we do not currently have uncertainty estimates for our wood volume and wood volume increment estimates, we had to analyse the possible effects of uncertainties using a model-based approach. In this approach, we apply the same yield tables that are applied in the forest inventory to estimate current annual increment (CAI), and silvicultural models (i.e. harvest models) that were developed by the end of the 1980’s, and that fairly model harvests in the country.
- The greenhouse gas estimates in this uncertainty analysis are thus not derived using the stock change method, which is otherwise used in the GHG estimation, rather, using the Gain-Loss method (equation 2.7 of the IPCC, 2006 Guidelines).
- It is, however, assumed that the two approaches would yield similar results in terms of both the GHG estimation and the uncertainty estimation (and especially with respect to the share of the uncertainty of the various factors in their contribution to the overall uncertainty). This is achieved by assuming a normal error distribution, with appropriate standard deviation, of the CAI (see table below), but no errors (uncertainties) in the silvicultural model. In other words, we assume that the uncertainties that we apply for CAI would take care of the uncertainties of the harvests, i.e. for the difference between CAI and harvests, which is equal to the volume stock changes.
- We also assume normal error distributions and respective standard deviations for basic wood density and for the root-to-shoot ratio (see the table below).

- All carbon stock change calculations are done by applying an appropriate carbon accounting model that implements equation 2.7 of the IPCC (2006) Guidelines with the above forestry models. This model, CASMOFOR, which is published by Somogyi (2010) and is freely available from the internet (http://www.scientia.hu/casmofor), is equipped with a Monte Carlo estimation module. Thus, the errors due to the above factors can be propagated in the calculations. In the Monte Carlo analysis, we repeated the calculations N=100 times in each separate analysis (see below).
- Finally, we assume that there is no correlation between the variables studied and their error distributions. This is justified because each variable has a physically/ecologically independent effect on the carbon stock changes.

For this analysis, we partly have country specific data (for basic wood density), partly we can assume uncertainties based on default values (for root-to-shoot ratio, in accordance with page 4.38 of IPCC 2003), and partly we have to apply expert judgements/assumptions (for wood volume change estimation). The relative standard deviations (STD) that are assumed and applied for the Monte Carlo analysis are summarized in Table 11.4.

Table 11.4. Assumed relative standard deviations for the variables that affect the uncertainty of the AB and BB pools.

Variable	Assumed relative STD (%)	Source
CAI	20 %	Expert judgement; assumption
Basic wood density	10 %	Somogyi, 2008 who found relative STDs between 5.7-12.7%
Root-to-shoot ratio	30 %	Expert judgmenet; IPCC 2003 (page 3.31: uncertainty of root-to-shoot ratio is assumed to be 30%, which corresponds to an SRD of 30 %)

Results

First, graphs are included below (Figure 11.4) that represent the quantified uncertainties due to the combined effect of the various factors on the carbon stocks. Each graph shows the development of the carbon stocks over time for the AR land as estimated by CASMOFOR. The green curves show the estimates without assuming any uncertainties (this could be regarded as “reference” curves when no uncertainties are assumed). The red-dotted curves are the mean values of the carbon stocks of all 100 runs of the Monte Carlo analysis. These curves are a bit different from the green ones, which may demonstrate the possible effects of the uncertainties as a whole, but also that the sample size has an effect, too.

(In this analysis, it is assumed that no afforestation takes place after 2008. This is not true, but it was not necessary in this analysis to assume any afforestatons beyond this year. This is the main reason that the curves level off after 3-4 decades, in reality, however, this would not happen as afforestations and reforestations have continued, and are planned to be continued, in future.)

The first two graphs in *Figure 11.4* also show the confidence interval, at the 95% probability level, of the carbon stock estimates for the AB due to the variance of the perturbed variables. The CASMOFOR model, however, is also able to provide an estimate of the carbon stock of the entire forestry system that includes all carbon pools, i.e., in addition to the biomass pools, the carbon stock of the soil, litter, deadwood and wood products pools are also estimated.

The development of the carbon stock and its confidence interval are shown in the second graph. We also present data for this entire system (“Total”), however, it is for information only.

The second group of graphs in *Figure 11.4* also shows, in addition to the reference and mean values, the ± STD values around the mean carbon stock values.

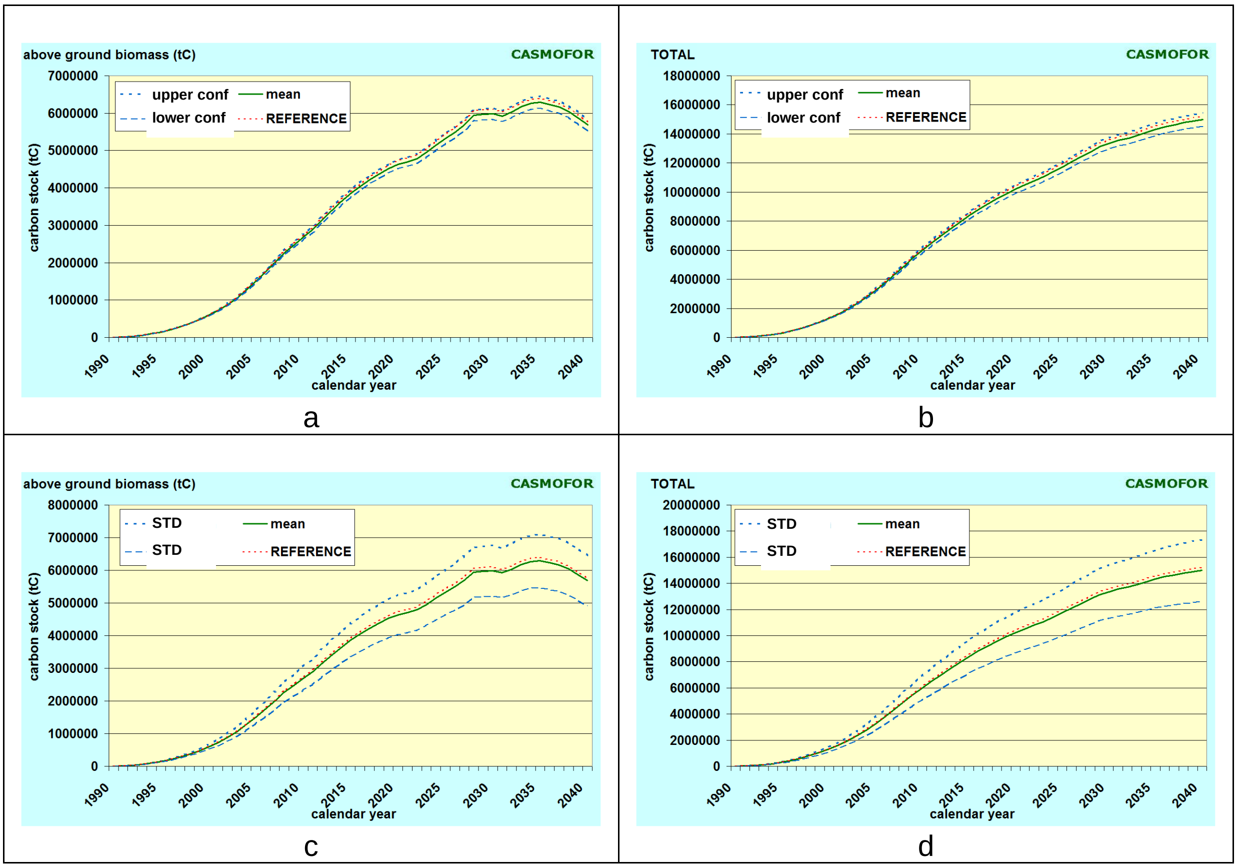
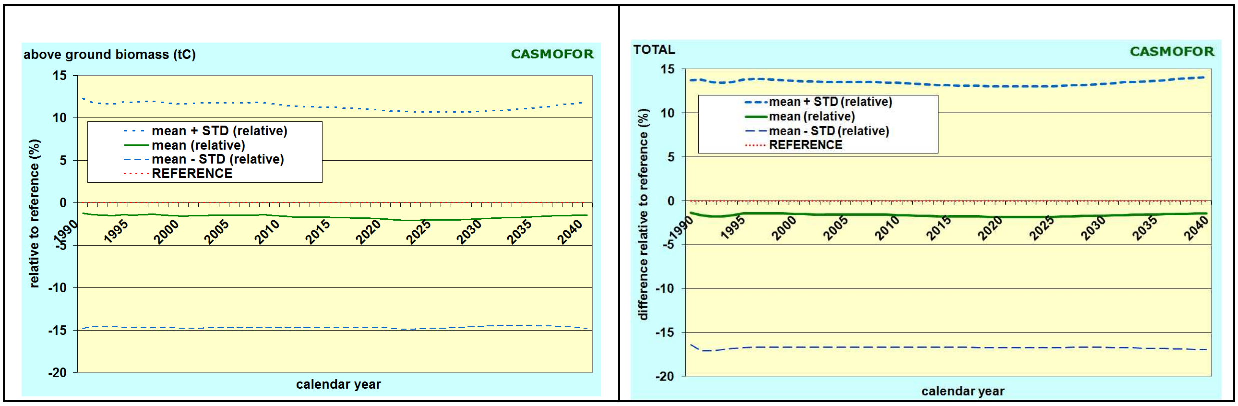


Figure 11.4. Confidence intervals (at the 95% probability level, a and b) and standard deviations (STD, relative to the mean value of the simulation of 100 runs, c and d) over time for AB (a and c) and the total forestry system (“TOTAL”, b and d) for the land under AR activities under the KP, as assessed by the Monte Carlo module of CASMOFOR.

The next two graphs (Figure 11.5) show, over time, the standard deviation of the carbon stock *changes* due to the combined effects of all three variables studied relative to the reference level (calculated as a ratio of the STD to the reference carbon stock value, in %).



a	b

Figure 11.5. Standard deviations relative to the reference scenario carbon stock changes for AB (a) and, for information, for the total forestry system ("TOTAL", b) for the land under AR activity under the KP.

The separate effects of the various factors can of course be analysed the same way (*Table 11.5*), i.e. by analysing STDs relative to the reference carbon stock changes. The data demonstrates that the uncertainty of CAI has the largest effect on the STD of the changes of both the AB and the total forestry system, whereas the root-to-shoot ratio has the largest effect on the BB.

Table 11.5. Separate and combined effect of the various factors (variables) on the STD of the carbon stock change estimate of AB, BB and all carbon pools (i.e. the above "TOTAL" forestry system), relative to the reference carbon stock change, for 2008 and for the land under AR under the KP, as assessed by the Monte Carlo module of CASMOFOR.

Variable	STD relative to the reference C stock change (%) in 2008		
	AB	BB	All carbon pools
CAI	11.8%	11.8%	12.3
Basic wood density	6.1%	6.1%	6.4
Root-to-shoot ratio	-	18.1%	3.6
Combined effect:	***13.5 %***	***25.1%***	***15.3%***

For AB, and for the inventory year 2008, the combined effect of the random errors of the variables studied amounts to an STD of 13,5% (Table 11.5), which, at the 95% probability level, corresponds to an uncertainty of

$\mathbf{U_{AB}}$ = 2 * STD * t(95%; DF=99) / sqrt(N) = 2 * 13.5% * 1,984 / sqrt(100) = **5.36%**

(DF = degrees of freedom).

For BB, and for the inventory year 2008, the relative STD is higher (Table 11.5), consequently, the uncertainty due to the combined effect of the random errors of the variables studied, calculated the same way, is also higher:

$\mathbf{U_{BB}}$ = 2 * 25.1% * 1,984 / sqrt(100) = **9.96%**.

The above calculations are based on data of our 2010 submission using data for 2008. As the overall data (e.g. total forest area) are not very different for 2009, the results of the above analysis are still relevant. Finally, because it provides detailed and valuable information, the above uncertainty estimation will be used in developing the GHG inventory in the future.

11.3.1.6 Information on other methodological issues

It is important to highlight that, although we use the best methods and data that is currently available, and that often represent Tier 2 or 3, we are not able to accurately estimate carbon stock changes always using Tier 2 or 3. Therefore, a highly conservative approach is applied in all steps of the inventory where the application of higher Tiers is not possible. This approach is characterized by always selecting data and methods that overestimate emissions and underestimate removals.

Generally, the area, harvest and forest fire statistics are based on annual assessments, whereas the emission factors and models applied are not based on the interannual variability of the physical environment. Therefore, the estimated emissions and removals are partly, but not completely, reflect the interannual variability of the true processes.

In principle, we use the same methods for estimating carbon stock change and non-CO_2 greenhouse gas emissions during the whole 1990-2009 period, thus, data reported under the KP is consistent with those under the UNFCCC. The same system, although with improved data coverage, is planned for the coming years, too.

With respect to the methodological Tiers applied in this report, at least the same or higher Tiers are applied as in our report under the UNFCCC. In general, higher tier, or at least methods of higher accuracy, are applied with respect to the identification and estimation of areas in the various land use and land use change categories under the KP. In general, Tier 2/3 is applied for AR, D and FM land: the land area identification is country-specific, and so is the estimation of volume, as well as that of the biomass conversion factor from volume to above-ground biomass. For the expansion of above-ground to total biomass, a Tier 1 factor is applied. The application of such a Tier 1 default factor is well compensated by selecting a conservatively low root-to-shoot factor, which may result in a bias in the estimation, but this bias is conservative as it is towards lower net removals.

With respect to QA/QC, the estimation, as well as QC has been done by the Forestry Directorate of the Central Agricultural Office, and the QA activities have been done by the Hungarian Forest Research Institute, in a similar fashion to the system applied for the preparation of the GHG inventory under the UNFCCC.

Almost all forestry data that have been used for the development of the GHG emission and removal estimates are collected, processed, aggregated and archived by the Forestry Directorate. Experts of the Directorate have participated in a training on the requirements and methods of developing the GHG inventory for the forestry sector. This system will ensure that all background data are collected and processed accordingly, and the number of possible sources of errors and uncertainties are reduced. On the other hand, the expert of the Hungarian Forest Research Institute used to develop the GHG inventory for the country, thus, is very knowledgeable about the needs, method and challenges of the development of the inventory.

11.3.1.7 The year of the onset of an activity, if after 2008

The Kyoto CRF tables, as well as data and calculations as demonstrated above, clearly and transparently indicate both the areas and the associated emissions and removals under Article 3.3 that have entered the accounting system. For Art. 3.4 FM, activity on all land is assumed to started before the beginning of the first commitment period. As a consequence, the Hungarian accounting fully complies with paragraph 18 of the annex to decision 16/CMP.1.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

For D and AR, field certificates of conversions exist by stand for the majority of the stands. These are archived and documented. Such certificates are only prepared for conversions that are inspected and proved to have taken place, i.e. where human activity has indeed occurred. These certificates are documented since 1 January 1990. Also, forest management plans are prepared for all stands in the AR category (see under section 11.5.1).

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

In Hungary, all forests must be regenerated after clearing mature stands by law (as defined by all Forest Acts since 1879, the latest one in 2009). There are very few exceptions to this rule. Regeneration usually means that a cut-and-regeneration sequence of operations is applied, which involves that most of the area that is cut in a year is void of mature trees for many years. Moreover, regeneration may start one or two years after the final cut is made. When the regeneration is established, it may take years, even a decade, for the seedlings to reach a height of one-two meters, and a full crown closure. In general, less time is needed to reach a crown closure of 30%, but more time may be needed in parts of the regenerations where the first attempt is not successful (where samplings cannot establish themselves due to, e.g., bad weather conditions, weed competition, game browsing and others). In general, the rate of closure and whether an area is cleared (deforested) or is under regeneration can only be monitored in the field.

There are country specific professional standards (as defined in the Implementation Rules of the Forest Act, 2009, practically unchanged for years) that set the time limits when regenerations (and afforestations) are deemed as successful.

According to the relevant decree, regeneration must be started by 31 May of the second year after land becomes subject to regeneration. “Successfulness” of regeneration means that it is believed that, except for rare extreme events, the regeneration continues to normally develop and can already be regarded a forest. This stage is defined by the following:

- species composition is within the limits as requested by the forest management plan
- even distribution of trees
- healthy tree individuals
- trees with main shoots in at least minimum number, usually eight thousand per hectare
- no invasive tree species
- minimum height of the main species reaches 1.5 m.

This stage is to be reached by time limits also defined by relevant decrees. The time limits depend on species and site conditions and can vary quite substantially (see Table 11.6 below). All areas that had to be regenerated have always been regenerated within these limits so far. In case the regeneration of an area is unsuccessful, it becomes part of the D category.

Table 11.6. Time limits of completing regenerations and afforestations (years after the area becomes subject to regeneration, e.g. after clearcutting)

Species	Regeneration type: Shelterwood cutting or selection cutting, years
Quercus pubescens, seed origin	12
Quercus petraea, seed origin Quercus robur, seed origin Quercus farnetto, seed origin	10

Fagus silvatica, seed origin	
Other species, seed origin	8
	Other types of regeneration, years
Quercus pubescens, seed origin	14
Quercus petraea, seed origin Quercus robur, seed origin Quercus farnetto, seed origin Fagus silvatica, seed origin	12
Coniferous sp. Quercus cerris, seed origin Other hard broadleaves, seed origin	10
Other species, seed origin	8
Any species of shoot origin	5

All AR and D areas, as well as those under regeneration are identified by the above mentioned forest compartments. These compartments have also been surveyed since 1 Jan 2008 for all information that is relevant for assigning them to the respective Kyoto forest categories (AR or D and, in case of regenerations, FM), as well as their location within each geographical area. It is also possible to identify each compartment in both the underlying database of this report (which is part of the documentation), as well as in the maps since 2008.

Harvests on afforested area have only been final cuttings in stands that have reached their rotation age. In cases an area is regenerated that was afforested or reforested earlier, the same rules apply by law than the ones for all other forests. These rules are based on the general principle that, in Hungary, all forests that are harvested must be regenerated. All areas under regeneration are continuously surveyed by the Forest Authorities, and tough penalties are applied to those that violate relevant rules.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

In Hungary, the Forest Authorities disclose a report each year on the current status of forests and forestry. This report includes the area of stands under regeneration. As Table 11.7 below demonstrates, this area varies around 120 kha on average. The same reports also state the area of final harvests each year which varied around 20-25 kha in the last three decades. From these numbers one can conclude that the average time a stand is regarded as “under regeneration” is about six years. Regeneration is basically treated the same way as afforestations and deforestations with regard to classifying them in a transition category such as “under regeneration”, and the same thresholds and criteria are in effect for a regenerated area as for an afforested area (see section 11.4.2 and Table 11.6 above, and section 7.2.3 of the NIR). Thus, the above mean length of period of six years is regarded as a normal value for this daily practice, regeneration. (Note here, too, that individual stands can be classified “under regeneration” for a much shorter or longer time depending on species, site fertility, weather and other local conditions that determine the success of the regeneration.)

Table 11.7. *The total area of stands under regeneration as reported by annual reports on forests and forestry.*

Reporting year	Area of stands under regeneration (ha)
1985	120043
1986	126120

Reporting year	Area of stands under regeneration (ha)
1987	128265
1988	130333
1989	132956
1990	132816
1991	136330
1992	135582
1993	133522
1994	127611
1995	120067
1996	116716
1997	115768
1998	112926
1999	110286
2000	112814
2001	113825
2002	115740
2003	117197
2004	117855
2005	118989
2006	119854
2007	120419
2008	123717
2009	125344

11.4.4 The amount of harvests for units of land that have been harvested

We report in our NIR afforestation and reforestation areas that have been harvested. Just like on land under all activities under the KP, and on forest land under the UNFCCC, carbon stock changes on these areas are established using the stock change method. Nevertheless, to comply with relevant requirements for this information, we report the total amount of harvests on these areas in Table 11.8. below.

Table 11.8. *The amount of harvests for units of land that have been harvested (2008-2009). (Note that some data for 2008 have been corrected.)*

Reporting year	Geographical location	Amount of harvests (m^3)
2008	North Hungary	17,730
	South Hungary	70,125
	Total	87,855
2009	North Hungary	19,395
	South Hungary	98,001
	Total	117,396

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Forest management plans are prepared for all forests of the country, i.e. all stands of both the AR and the FM category. These plans, which are parts of the underlying documentation, contain information, among others, on the status of the stand during the survey, long-term objectives, plans for short-term operations (for as long as a maximum 10-year period) and information on the last operations.

11.5.2 Information relating to Forest Management

11.5.2.1 That the definition of forest for this category conforms with the definition in item 11.1 above

FM land only includes managed forest areas that are included in the FL category, for which the definition of “forest” is applied as required by the Forest Act, as it is demonstrated above in section 11.1.,

11.5.2.2 That forest management is a system of practices for stewardship and use of forest land aimed at fulfil relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner (paragraph 1(f) of the annex to decision 16/CMP.1 (land use, land-use change and forestry))

All the principles defined in paragraph 1(f) of the annex to decision 16/CMP.1 (land use, land-use change and forestry) are among the principles of forestry of Hungary as set by law. The text of the most recent Forest Act (in Hungarian) can be found at http://www.vm.gov.hu/download.php?ctag=download&docID=4550.

11.5.2.3 Emissions and removals from Forest Management

The methodology is described in the section 11.3.1.1, General methodological notes.

11.5.3 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

As Hungary did not elect either Cropland Management, nor Grazing Land Management nor Revegetation, this is a non issue.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

The following key categories have been identified and reported in Table NIR 3 according to Chapter 5.4 of the IPCC GPG for LULUCF:
(1) CO_2 removals from Forest Management and
(2) CO_2 removals due to Afforestation and Reforestation activities.

Deforestation is not considered as a key category as the total emissions from this activity is smaller than the smallest category considered key in the key category analysis under the Convention.

11.7 Information relating to Article 6

In Hungary, no Article 6 projects took place in 2009.

11.7 NIR tables

TABLE NIR 1. SUMMARY TABLE
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[4]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	R	NR	NR	NR	NO			NO	IE	R	R
	Deforestation	R	R	NR	NR	R			R	NO	IE	R	R
Article 3.4 activities	Forest Management	R	R	NR	NR	NR	NO	NO		NO	IE	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

(1) Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(2) Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(3) N_2O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

(4) If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table NIR 1.1 Additional information
Selection of parameters for defining "Forest" under the Kyoto Protocol

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.50
Minimum crown cover	10 - 30 %	30.00
Minimum height	2 - 5 m	5.00

Table NIR 2. LAND TRANSITION MATRIX
Areas and changes in areas between the previous and the current inventory year (1), (2), (3)

From previous inventory year / To current inventory year		Article 3.3 activities: Afforestation and Reforestation	Article 3.3 activities: Deforestation	Article 3.4 activities: Forest Management (if elected)	Article 3.4 activities: Cropland Management (if elected)	Article 3.4 activities: Grazing Land Management (if elected)	Article 3.4 activities: Revegetation (if elected)	Other (5)	Total area at the beginning of the current inventory year (6)
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	158.62	0.00						158.62
	Deforestation		8.42						8.42
Article 3.4 activities	Forest Management (if elected)		0.45	1,656.68					1,657.13
	Cropland Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation(4) (if elected)	NA			NA	NA	NA		NA
Other (5)		3.52	0.00	0.00	NA	NA	NA	7,475.57	7,479.09
Total area at the end of the current inventory year		162.14	8.87	1,656.68	NA	NA	NA	7,475.57	9,303.26

(1) This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

(5) "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

(6) The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country and is constant for all years.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS [3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other [2]	
Specify key categories according to the national level of disaggregation used[1]					
Afforestation and Reforestation	CO_2	Forest land remaining forest land, Conversion to forest land	Yes	NO	NO
Forest Management	CO_2	Forest land remaining forest land	Yes	NO	NO

[1] See section 5.4 of the IPCC good practice guidance for LULUCF.
[2] This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.
[3] Describe the criteria identifying the category as key.
[4] If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

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URL: doi:10.1016/j.foreco.2008.11.002

12. Information on accounting of Kyoto units

Annual Submission Item	Reference / Information
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The SEF Report is submitted as a separate file created by the UNFCCC SEF Application v1.2. The filename is: [SEF_HU_2011_1_13-41-30 3-1-2011.xls]. (Report R-1)
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	There have been 1 discrepant transaction during the reporting period, pursuant to 15/CMP.1 annex I.E paragraph 12. The response code was 5103. Detailed information can be found in the Excel file named [SIAR Reports 2010-HU v1.0.xls] on sheet "R2". (Report R-2)
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2010. The above statement can also be found in the Excel file named [SIAR Reports 2010-HU v1.0.xls] on sheet "R3". (Report R-3)
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2010. The above statement can also be found in the Excel file named [SIAR Reports 2010-HU v1.0.xls] on sheet "R4". (Report R-4)
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2010. The above statement can also be found in the Excel file named [SIAR Reports 2010-HU v1.0.xls] on sheet "R5". (Report R-5)
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No discrepancies have occurred in the reporting period.
15/CMP.1 annex I.E Publicly accessible information	Publicly Accessible information is available at https://www.hunetr.hu/crweb/ under the "Nyilvános Jelentések" / “Public Reports” menu item. Publicly available information accessible on the website of the Hungarian National Registry are the following: - Account information detailed in 13/CMP.1 par. 45 are available at: https://www.hunetr.hu//crweb/reportAccountsList.do - Article 6 project information detailed in 13/CMP.1 par. 46 are available at: https://www.hunetr.hu//crweb/reportProjectList.do - Holding and transaction information detailed in 13/CMP.1 par. 47 are available at: https://www.hunetr.hu//crweb/reportTransactionInformation.do In line with the provisions of European Commission Regulation

	2216/2004, Annex XVI paragraph 7, holding and transaction information generally are made publicly available after the 15th of January in the year following the year of the transaction (points b,c,e,g,h,i,j,k). Detailed account holding and transaction information are only made publicly available after the 15th of January in the fifth year following the year of the transaction (points a,d,f,m). - List of legal entities authorized by party detailed in 13/CMP.1 par. 48 is available at: http://www.hunetr.hu/Modules/Main/unit_holding_permissions.pdf
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve is calculated in accordance with the annex to decision 18/CP.7, based on the inventory of 2009 (NIR submission 2011) Please see Ch 12.1. for CPR and details of the calculation.

12.1 Calculation of the commitment period reserve (CPR)

The commitment period reserve is calculated in accordance with decision 11/CMP.1 (Annex Article 6.):

"Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest."

At the time of the preparation of this document the "most recently reviewed inventory" is the inventory of 2008 (National Inventory Submission 2010), however the inventory of 2009 (National Inventory Submissions 2011) is already available and by the time this document will be assessed, the inventory of 2009 might already be the "most recently reviewed inventory", so CPR is calculated based on 2009's data.

Calculations:

(a) On the basis of assigned amount:
90% of the assigned amount of Hungary
542,366,600 x 0.9 = 488,129,940 Mg CO_2-eq

(b) On the basis of the inventory of 2009 (NIR 2011)
five times the inventory of 2009
66,659.83 x 5 = **333,299,158 Mg** CO_2-eq

12.2 KP-LULUCF accounting

For the time being, no RMUs have been issued, therefore no information on the accounting of the KP-LULUCF is included in the SEF tables.

Nevertheless, based on the latest KP-LULUCF inventory, Hungary expects to be able to issue 6,873,645 tonnes CO_2 equivalent as RMUs due to activities in 2008 and 2009 under Articles 3.3 and 3.4 of the Kyoto Protocol.

INFORMATION TABLE ON ACCOUNTING FOR ACTIVITIES UNDER ARTICLES 3.3 AND 3.4 OF THE KYOTO PROTOCOL

HUNGARY
Inventory 2009
Submission 2011 v1.6

□**Commitment period accounting: NO**
□**Annual accounting: YES**

Number of the reported year in the commitment period: 2

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	BY(5)	Net emissions/removals(1)			Accounting Parameters[7]	Accounting Quantity [8]
		2008	2009	Total[6]		
	(Gg CO_2 equivalent)					
A. Article 3.3 activities						
A.1. Afforestation and Reforestation						-2,313.97
A.1.1. Units of land not harvested since the beginning of the commitment period[2]		-1,134.29	-1,107.72	-2,242.01		-2,242.01
A.1.2. Units of land harvested since the beginning of the commitment period[2]						-71.96
Southern-Hungary		-21.39	-36.98	-58.37		-58.37
Northern-Hungary		-4.03	-9.56	-13.59		-13.59
All regions		NO	NO	NO		NO
A.2. Deforestation		34.70	81.47	116.17		116.17
B. Article 3.4 activities						
B.1. Forest Management (if elected)		-2,784.02	-1,891.82	-4,675.85		-4,675.85
3.3 offset[3]					0.00	0.00
FM cap[4]					5,316.67	-4,675.85
B.2. Cropland Management (if elected)	0.00	NA	NA	NA	0.00	0.00
B.3. Grazing Land Management (if elected)	0.00	NA	NA	NA	0.00	0.00
B.4. Revegetation (if elected)	0.00	NA	NA	NA	0.00	0.00

13. Information on changes in national system

After the elections in spring 2010, the ministerial structure has been changed significantly. The Ministry of Environment and Water has been abolished, most of its tasks and responsibilities have been taken over by the Ministry of Rural Development. Although climate policy related issues belong now to the Ministry of National Development where a Climate Policy Department has been established, the single national entity in relation to the national system is still the ministry responsible for the environment i.e. the Ministry of Rural Development. The institutes responsible for inventory preparation and compilation, mainly the Hungarian Meteorological Service, the Forestry Directorate of the Central Agricultural Office (CAO) and the Forest Research Institute are under the control of the Ministry of Rural Development. The national system has to be operated by the minister responsible for the environment as earlier but - as a new feature - in consent and cooperation with the ministers responsible for energy policy and forest management. The relevant pieces of legislation, e.g. Act LX of 2007 on the implementation framework of the UN Framework Convention on Climate Change and the Kyoto Protocol thereof, and the government decree 345/2009 on data provision relating to GHG emissions, have been amended accordingly.

14. Information on changes in national registry

Changes to Hungary's National Registry are reported for the following period: from 16 April 2010 to 15 April 2011.

The baseline for the reported changes is the latest Standard Initial Annual Report (submitted on 15 April 2010) and the Readiness Documentation. Changes to the national registry during the reporting period are detailed below. The reported information has been compiled in accordance with the provisions of the "SIAR Reporting Requirements and Guidance for Registries (v4.5)".

In the reporting period there have been no significant changes to the Hungarian registry.

To raise the security of the system, the Hungarian registry administrator has introduced a digital certificate system - each registered user has been supplied with a personal client digital certificate issued by the registry administrator. Since 27 December 2010 the website of Hungary's National Registry can only be accessed with the use of these certificates. Development of a two-factor authentication method is nearly done and as a result an SMS transaction signing system will be introduced to the registry in the very short term. Upon initiation of a transaction, the user who initiated the transaction will receive a one-time code to his/her mobile phone, which needs to be entered before the transaction is processed. The digital certificate system will remain in place beside the SMS transaction authentication.

Reporting Item	Reference / Information
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The registry administrator designated by Hungary to maintain the national registry - National Inspectorate for Environment, Nature and Water - has not changed. Contact information of the registry administrator has changed. For details please see section below of this document.
15/CMP.1 annex II.E paragraph 32.(b) Change of cooperation arrangement	There is no change in this subject. Hungary's national registry is operated as a standalone registry.
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of National Registry	No change to database or the capacity of National Registry
15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	No change in conformance to technical standards
15/CMP.1 annex II.E paragraph 32.(e) Change of discrepancies procedures	No change in the discrepancies procedures in the reporting period.
15/CMP.1 annex II.E paragraph 32.(f) Change of Security	No change in the security in the reporting period.

15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	No change in the list of publicly available information in the reporting period.
32.(h) Change of Internet address	Hungary's National Registry's Internet address is unchanged. The address is: www.hunetr.hu
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measure	No change in the data integrity measure in the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	No change in test results
The previous Annual Review recommendations	Previous Annual Review recommendations of the SIAR assessment are the following: Ref Nr: P2.4.2.1 Hungary reported that, in accordance with the relevant EU legislation, part of the account and transaction information to be made publicly available under paragraph 47 in the annex to decision 13/CMP.1 is considered as confidential for a period of time and, consequently, will be made publicly available at specified dates in the future. However, Hungary does not include a statement to this effect on its national registry website where public information is available. It is recommended that if Hungary considers information to be confidential, then Hungary should include a statement on the website that information is considered confidential and that any changes be reported in its next annual submission. Response: With the introduction of the client digital certificate system and the SMS based transaction signing (two-factor authentication method) the current implementation of publicly available information will need to be revised. The revision will start right after the implementation of the SMS system and is expected to conclude in May-June 2011.

Change in contact details of the Registry Administrator

The change in the contact details of the Registry Administrator is the following:

The primary contact is:

Name:	Mrs. Jánosné Tolnai Dr.
Position:	Deputy General Manager
Organization:	National Inspectorate for Environment, Nature and Water
Address:	Mészáros utca 58/a
City:	H-1016 Budapest
Tel.:	+36 12 24 9231
Fax:	+36 12 24 9264
E-mail:	tolnai.janosne@oktvf.gov.hu

Further contacts are:

Name:	Mrs. Anett Várkonyiné Antal
Position:	Head of Unit
Organization:	National Inspectorate for Environment, Nature and Water
Address:	Mészáros utca 58/a
City:	H-1016 Budapest
Tel.:	+36 12 24 9223
Fax:	+36 12 24 9264
E-mail:	vig.livia@oktvf.gov.hu

Name:	Ms. Lívia Víg
Position:	Expert
Organization:	National Inspectorate for Environment, Nature and Water
Address:	Mészáros utca 58/a
City:	H-1016 Budapest
Tel.:	+36 12 24 9190
Fax:	+36 12 24 9264
E-mail:	vig.livia@oktvf.gov.hu

15. Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

Information on how Hungary as a Party included in Annex I of the Convention is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement her commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

In accordance with Article 3, paragraph 1 of the Kyoto Protocol Hungary is committed to limit her anthropogenic carbon dioxide equivalent emissions of greenhouse gases listed in Annex A of the Protocol to such level that they are in line with Hungary's reduction targets while aiming at further emission reduction. Hungary is guided by the principle that ambitious national reduction targets shall be supported by a climate policy ensuring that adverse impacts on developing countries, such as carbon leakage are avoided. Hungary fully supports the endeavours, measures and implements regulations of the European Union targeting the avoidance of such impacts and fostering sustainable development, while in the same time also a specific policy framework has been put into practice.

The policy framework is laid down in Hungary's National Climate Change Strategy (NCCS) for the period 2008-2025, based on extensive scientific research, a wide public consultation process and impact assessment. The strategy adopted in February 2008 by the Hungarian Government guarantees that according to the principle of integration, climate policy is integrated into development policy as well, safeguarding that emission mitigation projects, cooperation fostering technological transfer and enhanced funding options for climate change related projects will play an integral role among future development projects. Climate research shall be integrated into other scientific studies and research activities and the business sphere shall be involved in climate friendly investments in developing countries.

For the time being Hungary does not take part in large scale development projects relating to climate change.